Outsourcing versus in-house production

Development of a make-or-buy decision model at Atlas Copco Rock Drills AB

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Abstract

The question regarding whether to produce in-house or to purchase from an external supplier is nowadays commonly highlighted as a central and strategic decision for manufacturing firms. Furthermore, the importance of creating a competitive and consistent make-or-buy strategy that is adapted to the context of the firm as well as to today’s dynamic business environment cannot be underestimated. Today, the division Surface and Exploration Drilling (SED) within Atlas Copco Rock Drills AB in Örebro lack a standardized and holistic process to support this decision making, why this is requested. Consequently, this master thesis aims to, in line with Atlas Copco’s business strategy, develop a decision model in order to facilitate the make-or-buy decision at the SED.

In order to be able to fulfill the purpose, a thorough examination of the contemporary academic findings was executed. Furthermore, as the requested make-or-buy decision model should be adapted to the firm’s contextual circumstances, SED’s corporate strategy was analyzed and interviews with concerned employees from different functions were conducted. As a result of this, an initial list of parameters that affect the make-or-buy decision was generated. Thereafter, how to decompose, measure and prioritize these selected parameters were determined. Additionally, if any parameter should be considered as a knockout criterion was established as well. Based on this, the first draft of the decision model was developed and presented.

An in-depth analysis regarding areas of improvements was thereafter executed, and the first draft of the decision model was updated accordingly. Inputs to this analysis were gained from an empirical investigation. In more detail, interviews at both SED and at external suppliers, a calculative case study where the first draft of the model was tested as well as a workshop at SED were all sources of additional inputs. Based on the outcome of the in-depth analysis, modifications of the first draft of the model was made which resulted in the final version of the make-or-buy decision model.

The result of this investigation can consequently be described as a corporate adapted make-or-buy decision model. The model is divided into seven steps, namely:

1. Core competence analysis
2. Determination of module characteristics
3. Configuration of the make-or-buy setup
4. Request of quotations to potential supplier
5. Volume flexibility, lead time and total cost analysis
6. Risk evaluation
7. Synthesis of above stated parameters, including the parameters:
   - time flexibility
   - impact on R&D operations
   - acquiring competitive knowledge
   - product flexibility
   - the opportunity to share risks
   - long-term capacity

Furthermore, the end-user needs to have an idea of what module and what assembly level that could be of interest and use the decision model in order to investigate whether to reject or proceed with this suggested make-or-buy setup. The model also illustrates the need of a regular re-evaluation of the decision made, in order to cope with the dynamic internal and external business environment. One additional advantage with the decision model is that it takes both quantitative and more qualitative aspects into consideration after which a holistic analysis of these can be made.
Acknowledgement

By finishing this master thesis, we put an end to our educational life and graduate as Master of Science in Engineering, Industrial Economy, at Linköping University. This time as students has given us a broad foundation of knowledge and we are now, with eager expectations, looking forward to what challenges our working life will contribute with.

We would like to take this opportunity to express our gratitude to Atlas Copco Rock Drills AB, and more specific to the employees at the division Surface and Exploration Drilling (SED) in Örebro, for the warm welcome and the genuine interest in supporting this investigation. We are especially thankful for the time and effort our supervisors Kajsa Asklöf Axin and Maria Brink have dedicated continuously during the compilation of this report. Further, the support and guidance given by our supervisor at Linköping University, Maria Huge-Brodin, have been very helpful and is much appreciated. Finally, we would like to thank our opponents, Anna Jonsson and Cecilia Holmgren, for their suggestions of improvements.

With that being said, we now wish you a pleasant reading!

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1 Introduction

In the following section, a brief background of the subject of this master thesis is presented. Thereafter, a problem definition is given in order to describe the circumstances regarding the assignment, which is followed by the purpose of this study. The purpose is subsequently clarified and, finally, directives and delimitations of the thesis are discussed.

1.1 Motive

The need to develop a competitive and consistent manufacturing strategy has become increasingly important in order to cope with today’s dynamic business environment (Platts et al, 2002). A central part of the manufacturing strategy is to determine whether to produce in-house or buy from an external part (ibid.). When making this make-or-buy decision, a fundamental motive to buy is to achieve cost reductions by accessing the suppliers’ economy of scale (Bengtsson et al, 2009). The opportunity to focus on core competence and gain access to the supplier’s knowledge is another central part that affects the decision (ibid.). Abrahamsson and Karlöf (2011) agree and state that the increased market competition has resulted in the need to focus on core competence and investigate what other parties can perform in a more effective way. In order to fully evaluate both the long- and short term effects of the different make-or-buy setups, these aspects are vital, but not sufficient, to consider (Platts et al, 2002; McIvor, 2007). A higher level of flexibility, shorter lead times and increased efficiency are some additional factors that are influenced by the decision and therefore need to be taken into account (Abrahamsson et al, 2003; Wee et al, 2008). Consequently, in order to successfully make this decision, a careful evaluation is necessary, as the outcome is highly context specific and depends on a wide range of parameters (ibid.).

A concept that is closely related to the make-or-buy decision is outsourcing. According to Abrahamsson et al (2003) outsourcing is the act of transferring existing and critical activities that are not core activities to an external third party. Van Weele (2010) agrees and further elaborates that outsourcing involves a deeper relationship that evolves over time.

The trend to move parts of the manufacturing process to an external supplier has increased dramatically throughout the developed economies of the world (Malmgren, 2010). A shift from only transferring non-strategic activities to the transfer of strategically important and business critical activities has also been recognized (ibid.). The removal of in-house activities has enabled firms to achieve cost reductions, gain access to supplier knowledge and focus on core competence (McIvor, 2007). However, many companies fail to develop strategies that fully take into consideration the long term effects of the firm’s internal capabilities (ibid.). Instead the strategies are often based solely on reduction of overhead costs which may result in the transfer and loss of critical knowledge and core activities (ibid). As a consequence of that, numerous firms fail in their outsourcing procedure and as a result of under-performing suppliers, several experienced companies nowadays seek insourcing as a replacement for outsourcing according to Moe et al (2013) as well as Antelo and Bru (2010). Once again, it becomes obvious that a truly thought through decision process is of great importance in order to make a successful make-or-buy decision.

1.2 Problem definition

Atlas Copco Rock Drills AB is a company that continuously faces the question of what to produce in-house and what to entrust an external supplier with. The company is a part of the Atlas Copco Group that develops, manufactures and markets drill rigs for mining and construction. Within Atlas Copco Rock Drills AB there are several production units that belong to different business divisions. This study is executed at the division Surface and Exploration Drilling (SED) in Örebro. Atlas Copco Rock Drills AB acts with a strong customer focus in order to create sustainable value for their customers, shareholders and employees, consistent with the Atlas Copco Group’s business strategy. Last year a merge was initiated between Atlas
Copco Rock Drills AB and Atlas Copco Craelius AB, another production unit that acts within the same business area. This strategic move will result in the integration of an additional production line at SED.

Today, SED purchase on several different levels that differ in various degrees of assembly. Hence, the degree of purchasing level affects the amount of in-house assembly that is required. On the highest level, two complete rig models are ordered from external suppliers. Furthermore, for the rig models that are assembled in-house, the modules power pack and cabin are produced by suppliers. This external module assembly corresponds to the next highest level of purchased components. Apart from these levels, material is also purchased in lower degrees of sub-assemblies and, on the lowest level, single articles are bought and stored in-house based on demand and forecast.

Furthermore, SED recognize that there is a need to develop a suitable make-or-buy strategy. More specifically, the strategy should aid the decision of whether it is best to buy single articles or sub-assemblies for in-house production or to buy more processed assemblies or complete rig models from an external part. In order to support such decisions in the future, a make-or-buy model, that is adapted to SED’s needs, is required. Moreover, due to the integration of Atlas Copco Craelius AB, SED request a common and standardized make-or-buy philosophy. Additionally, there are requirements from the Atlas Copco Group to improve flexibility in order to meet the increased market challenges. Specifically, there is a need to manage the fluctuations in market demand, but at the same time fulfill the requirements on low costs, short lead times and low stock levels in agreement with the corporate business strategy.

1.3 Purpose
The aim of this study is to, in line with Atlas Copco’s business strategy, develop a decision model in order to facilitate the make-or-buy decision at SED.

1.4 Purpose clarification
As the purpose states, the decision model will be developed in agreement with Atlas Copco Group’s business strategy and directives. More specifically, it is SED’s production strategy that is of interest in this investigation. Furthermore, the purpose of the decision model is to facilitate the process of deciding whether to assemble in-house, and to what extent, or transfer to an external supplier. It is hence desirable that the model is of a generic nature, so that it can be applied even if the current circumstances and product portfolio change. Moreover, it is essential that the model is user friendly and that it presents a clearly specified procedure for how to make the decision. The aspiration is to provide a holistic and thorough method than can aid the decision making process.

The aim of this investigation is thus to develop a generic model that can facilitate the make-or-buy decision. In order to clearly specify the procedure for the decision making process it is important that the model is thorough, with step-by-step instructions. By following these steps, what to do and how to do it should hence be clear to the end-user. The model will thus be presented as a figure which clearly illustrates the decision making process. Moreover, the supervisors at SED are representatives from the production function, which request the model. Nonetheless, as the make-or-buy decision is a complex decision which highly impacts the other functions at the firm as well, the end user is expected to be a team with representatives from several of departments.

In order to achieve this aim, it is relevant to initially consider which main parameters that affect the make-or-buy decision. It is also necessary to evaluate which parameters that are important to include when constructing the decision model. These questions will thus act as an initial guide when constructing the theoretical framework.

1.5 Directives and delimitations
A directive that has been given from the supervisors at SED is that the higher purchasing levels should be prioritized in the decision model. To be more specific, the higher purchasing levels regard the acquisition
of modules with a high degree of assembly, or even complete rigs. Moreover, the input which is under consideration when using the model will further on in this study be referred to as simply module. The reason for this request is that purchase on these assembly levels has a more significant impact on the achieved result. Moreover, the focus in this investigation is to develop a framework for managing the make-or-buy decision and to determine the appropriate in-house assembly level. The study will not include an investigation on how to determine whether a specific supplier is appropriate or not, as a consequence of given directives. In addition, SED already has a valid process for supplier evaluation and selection and hence this is not requested, according to the supervisors at SED. Additionally, an analysis regarding how the supplier relationship should be implemented will not be provided either, as this aspect is not included in the scope of this study. However, it is necessary to include the supplier in the investigation in order to generate qualified estimations of the analyzed parameters. Furthermore, a prerequisite for using the model is that the end-user provides the purchasing level as an input. Consequently, the end-user needs to have an idea of what assembly level that could be of interest and use the decision model in order to investigate whether to reject or proceed with this suggested make-or-buy setup. Thus, the model will aid the make-or-buy decision, given a specified assembly level of a specific component.
2 Company presentation

In this section a brief presentation is given of Atlas Copco Group AB, including divisions and business areas. Thereafter, the business area Mining and Rock Excavation and the division Surface and Exploration Drilling are presented. Finally, a more detailed description is given of SED Örebro and how the unit operates. If not otherwise stated, all information is collected from the Atlas Copco IMS portal.

2.1 Atlas Copco Group

Atlas Copco Group is a market leader that provides sustainable productivity solutions. The company develops products and services within the four business areas; Compressor Technique, Industrial Technique, Mining and Rock Excavation Technique and Construction Technique. The Atlas Copco Group was founded in Sweden 1873 and have a strong market presence in more than 180 countries, with 44 000 employees. The company’s head quarter is located in Stockholm and in 2014 the annual turnover was approximately 94 BSEK (10,3 BEUR). Furthermore, the Group acts with a strong customer focus guided by the vision “First in mind – First in choice”. This means that there is an aim to be the obvious choice for existing and potential customers, as well as other stakeholders. The corporation also strives to be perceived as an innovator that sets the standard and exceeds the highest of expectations. Atlas Copco Group’s mission is to provide sustainable profitable growth, by responsible use of human, natural and capital resources and by supplying reliable and high quality products and services.

Atlas Copco Group’s core values; interaction, commitment and innovation, reflect what the corporation stands for and what it takes to serve their customers effectively, see figure 1 to the right. Interaction refers to the ability to listen and develop close relationships in order to understand the specific needs of different stakeholders. With a strong belief in long-term relationships, the firm is highly commitment to each customer and each project. Finally, Atlas Copco Group aims to be innovative and always improve existing solutions, in line with the belief that there always is a better way of doing things. These values thus describe both how the Group acts internally and in relation to external parties.

Figure 1: Atlas Copco’s core values

Furthermore, Atlas Copco Group is a decentralized organization which is structured in four focused, but still closely related, business areas as seen in figure 2 below. Each business area is responsible for developing, implementing and following up the objectives and strategies within the business scope. Moreover, each business area is divided into 4-7 divisions which are further focused on different specializations within the business area, see figure 2 below. Each division is further represented in several countries and is responsible for yielding both operational and consolidated profit. Although the corporation is organized in separate business areas and divisions, the Group is unified with a strong culture, shared visions, common processes and a cohesive leadership model. Within the Atlas Copco Group, resources and infrastructure support is also shared as well as human and financial resources which are mobile.
2.2 Mining and Rock Excavation Technique
The business area Mining and Rock Excavation Technique is focused on providing equipment for drilling and rock excavation to a world-wide market. The primary manufacturing units are located in Sweden, the United States of America, Canada, China and India. With a focus on supplying customers with high productivity enhancing solutions the business area offers a wide range of products as well as related consumables and services. The products are specified in different markets including surface and underground mining, infrastructure, civil works, well drilling and geotechnical applications. Mining and Rock Excavation Technique had an annual turnover of approximately 29 BSEK, in 2013, and is the second largest business area in the Atlas Copco Group, as only Compressor Technique yields a higher turnover. Additionally, the business area had roughly 13 300 employees, in 2013.

Furthermore, Mining and Rock Excavation Technique is divided into the six division; Mining and Rock Excavation Service, Underground Excavation, Surface and Exploration Drilling, Drilling Solutions, Rock Drilling Tools and Rocktec.

2.3 Surface and Exploration Drilling
Surface and Exploration Drilling is a division within the business area Mining and Rock Excavation Technique, which is illustrated in figure 3 below. The division is focused on developing, manufacturing and marketing equipment for primarily open cast mining, geotechnical drilling, quarries, construction work, dimension stone industry and civil engineering. Furthermore, the developing and manufacturing units within the division are currently located in Sweden, China, Austria, Italy, Japan and India. The head quarter of the division is located in Örebro, Sweden, where the more complex surface and exploration drill rigs are manufactured. This production site is also the largest, with approximately 300 employees. Apart from Sweden, two fairly large production units with approximately 100 employees are also located in Austria and China. These units are focused on crushers and screeners and the manufacturing of less complex rigs, respectively.
2.4 Atlas Copco Rock Drills AB

Several separate units within the business area Mining and Rock Excavation Technique are located in Örebro. These units are collectively gathered in the legal company Atlas Copco Rock Drills AB which is a subsidiary to the Atlas Copco Group. The company was founded in 1961 and had a turnover of approximately 9 BSEK 2013. Furthermore, this company includes units from the divisions Underground Rock Excavation, Surface and Exploration drilling, Rocktec and Mining and Rock Excavation Service. Altogether, there are approximately 1 900 people employed at Atlas Copco Rock Drills AB, where the Underground Rock Excavation is the largest unit with over 700 employees.

As the units belong to different divisions, this consequently implies that the units operate rather independently. In more detail, the units cooperate to a greater extent with the other units which act within the same division. However, due to the proximity, some collaboration within the company is convenient. For example some of the suppliers, as well as other resources, are shared.

2.5 SED Örebro

This study, as mentioned earlier, will be executed at the part of Atlas Copco Rock Drills AB that belongs to the division Surface and Exploration Drilling in Örebro. In order to simplify for the reader, this production unit will further be referred to as only SED. Furthermore, manufacturing was initiated at SED in Örebro 1995, as a result of transferring a production unit from Bremen. In the beginning of the 21st century the market demand increased, and SED’s manufacturing volume escalated. However, after the financial crisis 2008 SED, as most companies, faced a noticeable decrease in demand and thus had to adapt their organization. Since then, market demand has slowly increased and today SED has approximately 300 employees.

In 2013, a merge was initiated between Atlas Copco Rock Drills AB and Atlas Copco Craelius AB, as previously stated. Moreover, Craelius acts within the same business area and the move will result in the integration of an additional production line at SED.

2.5.1 Vision, mission and production strategy

The vision at SED is “to create the best value for our stakeholders by offering leading edge surface drilling technology solutions”. In order to fulfill this vision, a corporate mission is settled. Not all of the parameters that are concluded in this mission are of relevance for the execution of this investigation, but
below the statements of the mission which directly affect the production and, consequently, this study are highlighted:

- Develop, manufacture and market premium products with competitive TCO (Total Cost of Ownership) and high availability according to market needs
- Develop a flexible operation with low capital cost
- Continuously reduce cost and improve profitability
- Efficient production unit organized in flow concept, concentrating on core activities
- Continuously improve quality, adjustments and working capital

Furthermore, the mission states that a global cooperation between Atlas Copco companies should be supported. It also states that a cross-functional way of working should be developed and improved and, finally, that the Atlas Copco core values always should be lived by all employees. In order to specify how this mission should be achieved, strategies that act as guidelines have been established. Below, the strategies that relate to the perspective of the production department are summarized.

Firstly, focus should be aimed on safety, quality and reduction of the total production cost throughout all processes and activities performed at the firm. Secondly, the production operations should be flexible in order to manage market demand swings and protect customer lead time without taking any unnecessary risks. Considering the lead times, efforts should continuously be made in order to reduce these, both up-stream and down-stream in the supply chain. Furthermore, there should be a balanced approach regarding subcontractors and concerning capacity flexibility, it can be obtained through right balance between consultants and fixed employees. The continuous cost reduction is supported by optimized resource utilization as well as through increased modularization and standardization. In order to create an efficient production plant, the work should be performed according to the principles of “The way we produce”, continuously support flexibility in the production and by focusing on on-time-delivery. “The way we produce”, illustrated in figure 4 above, consists of the following ten principles: produce to demand, balanced work and flow, correct from me, standardized work, visual control, develop people, grow with suppliers, learn and improve, safe and healthy work environment and care for the environment. Finally, in order to create an efficient assemble unit, continuously improvements regarding stock reduction should be made and there is an ambition to achieve a zero manufacturing stock.

2.5.2 Organization
SED is structured in different functional areas, which each have their respective responsibilities and internal hierarchy. In figure 5 below, an overview of SED’s organization is provided.
Production
The production function is in charge of the assembly of the rigs and the administrative operations which are tied to the assembly. Among other tasks, the production function is in charge of planning the production, starting and managing the customer orders in the system and handling the daily contact with suppliers. Moreover, when an order is made the function is accountable for making sure that the necessary articles and components are ordered and delivered in time. The function is also in charge of the different production lines and assembly stations. Thus, production makes sure that the supply of materials and assembly works according to plan, which includes analyzing the capacity that is needed both in the long and short term. Depending on the configuration, purchasing on higher levels could thus result in the management of fewer articles for the production function.

Strategic Purchasing
Strategic purchasing is responsible for finding the best possible supplier for a given component or article. This includes handling negotiations with the suppliers and writing contracts, which are revised and updated on a regular basis. In order to enable a closely integrated relationship with each of the more strategic suppliers, a strategic purchaser is assigned to an individual supplier. Furthermore, the function works proactively and is in charge of helping the supplier to achieve given requirements or changes. As the chosen suppliers and contracts have a large impact on the company’s products it is vital for strategic purchasing to have a good collaboration with the other functions within SED. The function is, hence, greatly affected by the make-or-buy decision, as they are responsible for the relationship with the more strategic suppliers.

Marketing
The marketing function is in charge of promoting the products to customers through customer centers. It is also their responsibility to evaluate offers and demands from customers in order to deduce whether it is advantageous to sell or not, and to what terms. Moreover, the function makes prognosis of expected sales, which is used by suppliers and the production function in order to plan the production. As marketing handles the interaction with customers, it is important that they are closely integrated with the other functions in order to convey the customer’s opinions and to fully understand the implications a given deal has on the internal production. The primary focus of the market function is to satisfy customers, often by promising quick deliveries. Hence, the function is affected by the make-or-buy
decision in the instances where purchase of higher or lower levels has an impact on the lead time or quality of the products.

**Research and Development**

The research and development function is responsible for continuously developing existing and new products in order to ensure that the company stays innovative and that the customers’ needs and requirements are fulfilled. Thus the function is accountable for coordinating and implementing all construction changes. Another important task of the department is to decrease the assembly time in the production, especially when introducing a new technical article or modifying an existing one. Regarding the make-or-buy decision, it is hard to deduce how the function is impacted as it strongly depends on the nature of the make-or-buy configuration and the specific supplier. In general, however, it is often easier for research and development to quickly improve the quality if the components are produced in-house. On the other hand, in some instances, collaboration with suppliers has enabled SED to access further knowledge and thus improve their product development.

2.5.3 Products

The drill rigs, see example in figure 6 below, that are manufactured at SED today are primarily used for construction work, blast hole drilling at open cast mining and geotechnical drilling, but the field of application also includes quarrying and civil engineering. The customers are located worldwide where Norway, Australia, Russia, Thailand and USA account for a large amount of the sales. SED offers three main product series of hydraulic surface drill rigs, including approximately 30 rig models altogether. The models mainly differ in degree of automation, size and appropriate application area. The most advanced rig models belong to the SmartROC series, characterized by a highly automatized and intelligent system which contributes to superior productivity for the user. FlexiROC is a rig series which includes flexible models with a high variety of features and with the possibility to adapt to different application fields. Further, this series offers radio remote controlled rigs without cabin, which highly improve safety during usage. Finally, the series PowerROC is mainly characterized by sustainability and robustness. Within the three rig series, a wide range of different models is offered, diverging in drilling type and in optimal nominated hole diameter. Additionally, the customers have several options to choose among, for example winch, seat warmer, engine types and water cistern.

**Product structure**

The drill rigs that SED manufacture consists of the main components wagon frame, boom, feed, rock drill, fuel and hydraulic tank, valve plate, power pack, cabin, track frame, electronics pack and the software. Beginning with the wagon frame, it is the basic structure that all other components successively are assembled onto. Similarly, the boom is the basic frame that carries the feed and hence one of the more central parts of the rig. The feed is also a key component as it enables localization and extension of the rock drill and attachments of additional drill bits. Moreover, other main parts of the drill rig are the fuel and hydraulic tank, which are directly connected to the power pack. The power pack, in turn, contains the engine of the rig. Other main components of the drill rig are the cabin and the track frames. Other central parts of the rig are the electronics pack and the software. Apart from these main components, a large amount of smaller components and articles are also part of the rig.

2.5.4 Production

At SED, no manufacturing is performed and refinements of the products solely consist of pure assembling. The in-house production of a drill rig starts when initial assemble of the modules valve plate, fuel tank and hydraulic tank is initiated. These pre assemblies, as well as assemble of the boom, are performed at given stations formed to enable the included operations. Parallel to this, the feeder pass through a flow
oriented initial assemble line. Finally, the rig enter the final assemble flow. Here there are two separated production lines, the L-flow and the D-flow where the former is adapted to the larger rig models and the smaller rigs are assigned to the latter. These two production lines have different production rates and number of assembly stations. The final assemble flow starts when a wagon frame arrives to the first flow station. Thereafter, both modules at higher purchasing levels and single components successively are added throughout the final flow. As an ending point at each final assemble line there is an electrical testing station and subsequently the rig is filled up with fluids and started to control that it functions without implications.

2.5.5 Material sourcing strategies
SED utilizes four different material strategies for purchasing material. The first and most commonly used strategy is material requirement planning (MRP), where material is order based on prognosis. Another strategy that is used for more frequent and cheaper articles is the physical order point. This strategy implies that when a certain article reaches a calculated stock level, an order is made. Furthermore, for some of these commodities a vendor management inventory is used. Hence, the suppliers are in charge of monitoring the stock levels in order to ensure that enough of these articles always are in stock. Currently, this strategy is only used on fuel and nipples. The last material strategy is call off. This strategy is used for option based modules or other components which are customer specific and thus disadvantageous to keep in stock. Furthermore, this strategy implies that ordering from the supplier is not done until the product has been sold to a customer. This strategy is for example used on the cabins, power pack and the hoses.

Should an error be detected, either in the production or when testing the final product, an investigation is started to detect the source of the error. The aim of this investigation is to clarify what went wrong and prevent it from happening again. Thus, if the error occurred in the internal production, actions are taken to inform the responsible personnel or improve the production processes or equipment. Similarly, if the error is traced back to the supplier, and a fault in the purchased material, a process is started in order to inform the supplier of the deficiencies. In the case of single articles or smaller sub-components, this process can result in the return of goods, which are replaced by new ones by the supplier to no additional cost. Should problems with a specific supplier persist, however, larger actions are taken to prevent these or, in the worst-case scenario, the supplier is ex-changed.

Regarding the larger modules, return of articles to the supplier is much more uncommon. Rather, the responsible supplier sends personnel to SED in order to fix any problems that SED lack the competence to correct. In most instances, however, SED are able to correct the errors themselves, by investigating the problem thoroughly. Furthermore, in the contracts with the suppliers, it is specified that the suppliers are responsible for paying the cost of tracing and fixing errors that occur due to them. In the rare instances where any problems with the larger modules cannot be fixed easily, and thus affect the lead-time to the end-customers, however, it is not specified if the supplier should be responsible for this cost as well. Hence, in such instances, a dialogue and mutual agreement with the specific supplier is necessary.

2.5.6 Atlas Copco Craelius AB
Atlas Copco Craelius AB has historically been an individual firm within the business area Mining and Rock Excavation Technique. As previously mentioned, the firm has recently been legally integrated with SED although the production sites are still separated. In the future, however, a full integration is planned where the productions sites will be common. In order to facilitate the description of the part of SED that historically have been Atlas Copco Craelius AB will be referred to as Craelius, despite that no such division exist anymore.

Craelius develops, manufactures and markets equipment for different applications within the areas exploration drilling, foundation and rock enhancement. As the market that Craelius acts on is rather unstable, there is a high demand on flexibility. Thus, Craelius have been utilizing external staffing
companies which have enabled them to easily adapt to the varying capacity requirements. Moreover, some of the production models that are hard to integrate in the production have been transferred to an external supplier, supplier A. This supplier is also responsible for buying and storing the components that are needed for the manufacturing, which have enabled Craelius to clear space internally and liberate capital. Furthermore, the agreement with supplier A allows Craelius to manufacture the production models themselves when desired. Thus, when the internal production is low, Craelius have the possibility to occupy their employees by producing these rig models internally. In this case, supplier A delivers the material to Craelius at the desired assembly level. Hence, Craelius have the ability to even out their production by adjusting the amount of external production.

2.5.7 Current make-or-buy setup

Today SED purchase material on several different levels. On the highest level, complete rigs are ordered from subcontractors. These rigs are smaller and less advanced and thus hard to integrate in the existing in-house assembly lines. In addition, there is limited production space why it is beneficial to not produce these internally. Moreover, these two rig types are bought from supplier B and C. The collaboration with supplier B is characterized by a high degree of independency and apart from the assembly, supplier B is in charge of buying and storing needed material as well. Thus, SED is only responsible for receiving customer orders and design development. Considering supplier C, SED store and kit all material whereupon the kitted material is sent to the supplier for assembly.

On the next level of purchased material, sub-assembled modules are bought from external suppliers. The ordering of these modules is not done until a customer order has been received. In specific, acquisition of the power pack module is made from supplier D. Besides from producing the power pack, supplier D buys and stores the necessary material. However, SED is responsible of the design specifications of the products. Similarly, the cabin module is purchased from supplier E. This supplier manage the purchasing, with the help of detailed prognosis which SED provides, as well as storing, partial manufacturing, assembly and final testing of the cabin. Furthermore, although supplier E is in charge of the design specifications of most of the included products, SED specifies the following components: chair, electronics, screens, joy-sticks and the climate system.

Most of the material, however, is purchased in lower degrees of sub-assemblies and single articles. These levels correspond to the two lowest purchasing levels of material. Regarding the sub-assemblies, these vary in the number of assembled articles and complexity. The material sourcing strategy for this level is material requirement planning. Finally, on the lowest purchasing level, single articles are bought and stored in-house based on demand and forecast. These articles are obtained from a number of suppliers on a regular basis in accordance with the sourcing strategies VMI and physical order point.

Moreover, the reason why there are several different make-or-buy setups is a result of independently taken strategic decisions. For example, the power pack module was earlier manufactured in-house, but due to lack of production space and a limited number of assemblers, it was transferred to an external supplier. Regarding the rig models that today are assembled by external suppliers, they were outsourced as a consequence of the difficulty in integrating these models into any of the two final assemble lines. Thus, each of these make-or-buy setups is a result of a strategic decision. However, there is a lack of common, standardized and holistic strategy regarding the level of purchasing and in-house assembly. There is also an absence of a strategy that takes into consideration the dynamic internal and external business environment and re-evaluates the chosen decisions on a regular basis.
3 Theoretical framework

Initially, this chapter provides an introduction to the outsourcing issue, a description of the different degrees and prerequisites of outsourcing. Thereafter, opportunities, risks and costs regarding the outsourcing decision are discussed. Finally, a review of existing decision model theories is presented.

3.1 Effective supply chains

The process approach is well recognized by organizations nowadays and the implementation degree of this philosophy increase successively according to Oskarsson et al (2013). This consequently implies that the function oriented way of thinking is becoming less frequent and there is a trend towards an increased integration between, not only the internal functions within a firm, but also an extended external integration (ibid.). By utilizing the strengths of the supply chain and its members, an organization can acquire benefits as reduced total costs, inventory reductions, improved delivery service, shorter product development cycles as well as shorter lead times to the end customer according to Fawcett et al (2008). It is further stated, by Fawcett et al (2008), that the main objective of establishing strategic supply chains is to mobilize resources in order to create sustainable competitive advantages that one standalone firm would find it hard to accomplish. According to Defee and Fugate (2010), today it is not organizations but rather whole supply chains that compete at the market.

However, Defee and Fugate (2010) state that cross-organizational relationships take time to develop, why the benefits need to be looked upon from a long term perspective. Furthermore, there are obstacles that need to be tackled in order to acquire the benefits from the collaboration within the supply chain according to Fawcett et al (2008). These can be categorized as either inter-firm rivalry, which are barriers arising from the organization itself and its employees, or managerial complexity (ibid.). Within this category, obstacles as information system and technological incompatibility, insufficient measurement methods and inappropriate organizational structures can be found according to Fawcett et al (2008). However, the greatest barrier to a successful supply chain is, what Fawcett et al (2008) call the people issue, including aspects as culture, trust and aversion to change and information sharing.

Defee and Fugate (2010) further indicate that an efficient supply chain require all members to understand each other’s strengths and capabilities. When this knowledge is acquired, it allows the location and allocation of activities so that they are performed by the most appropriate party in the supply chain (ibid.). This will further result in an increase in the overall performance of the supply chain, as it enables a higher degree of focus which in turn allows a higher productivity level according to Defee and Fugate (2010). However, in order to achieve this, there is a need of efficient information sharing, above stated as one of the greatest obstacles to an effective supply chain by Fawcett et al (2008). Moreover, Fawcett et al (2007) opine that both connectivity regarding the chain members’ information technology and willingness to share information need to exist in order to make the information sharing in the supply chain account as effective. A high degree of fulfillment in both these information sharing dimensions allows a firm to outsource part of its business, as one way to efficient and effectively collaborate in the supply chain, according to Fawcett et al (2007).

3.2 Introduction to outsourcing

Dolgui and Proth (2013) opine that the question, concerning in what extent production should be performed internally and what could be entrusted an external supplier, always arise when a firm face an implementation of a new product. As an addition to this statement, Kumar et al (2010) stress the importance of regular re-evaluation of the present make-or-buy strategy in order to make it fit the current situation of the firm. What these authors, among others, agree upon is the importance of creating a competitive and consistent make-or-buy strategy that is possible to adapt to today’s dynamic business environment.
According to Dolgui and Proth (2013), outsourcing is defined as “the act of obtaining semi-finished products, finished products or services from an outside company if these activities were traditionally performed internally”. Similarly, Abrahamsson et al (2003) state that outsourcing is the act of transferring existing activities, which are not core activities, to an external third party. Nordigården et al (2014) add to this terminology discussion that the transference of an activity include the transference of the control of the activity as well. Van Weele (2010) contributes with the statement that the outsourcing approach involves a closer relationship, between the concerned parties, that evolves over time.

One of the main drivers of outsourcing is companies’ strive to increase competitive advantages through cost reductions (van Weele, 2010; Abrahamsson et al, 2003). The cost reduction driver is closely followed by the motive to be able to focus on core activities. Ellram and Billington (2001) further state that outsourcing is a way to gain access to the knowledge and resources of the supplier market. Nowadays, however, outsourcing is more often considered as a way to achieve strategic objectives and the decision, whether to make or buy, should therefore be carefully evaluated according to Abrahamsson et al (2003). This is supported by McIvor (2000) who stresses that there is a need to develop an outsourcing strategy, which preferably should be integrated into the overall strategy of the firm, and that the decision should take a long-term perspective.

3.3 Degrees of outsourcing

Material sourcing can be performed to different extents, and the traditional approach is that a firm acquires a high number of parts from a wide range of vendors. In such cases, the buying firm has a high manufacturing penetration and benefits from economics of scale can be obtained through standardization of the separated parts. (Arnold, 2000)

Further, as stated by Arnold (2000), the next degree of outsourcing is to transfer a higher amount of the manufacturing responsibility to an external supplier. Thus, when this sourcing concept is applied, whole modules are bought from the first tier supplier (ibid.). These modules are normally highly customer specific and delivered to the buying firm just in time for final assembly (ibid.). Moreover, according to Mikkola (2003), modular product design which allows this modular sourcing approach enables higher degree of specialization. Due to increased complexity and advanced technology, external suppliers are able to achieve specific activities to a lower cost as well as with higher value adding, and the buying organization can benefit from the suppliers economics of scope through outsourcing of these activities (ibid.). In addition, Mikkola (2003) state that modular outsourcing only can be executed when the product can be decomposed in distinctly defined sub-components with well specified and standardized interfaces.

3.4 Prerequisites for outsourcing

In order to be fully prepared and able to make a successful decision concerning outsourcing, the firm needs to accomplish some foundational tasks, according to Brown and Wilson (2005). Firstly, it is of vital importance that the outsourcing decision is consistent with the organization’s overall strategic goals. Secondly, the firm’s core competences need to be identified. Thirdly, the supplier markets need to be investigated in order to determine whether there are any appropriate suppliers available or not. As a final task for the firm to undertake as a prerequisite of outsourcing, a team responsible for the outsourcing implementation needs to be formed. (Brown and Wilson, 2005)

All of the four steps that Brown and Wilson (2005) discuss are of high importance in order to successfully outsource to an external party. In this investigation, the focus is on what level to buy on and not how to choose a suitable supplier or implement the decision. Hence, step three and four are outside the scope of the study and will not be discussed in more detail. However, it is unavoidable to include the supplier in the investigation, as stated in section 1.5 and it is necessary to assume that a search for suitable suppliers will be executed.
3.4.1 Consistency with the overall cooperate strategy
Brown and Wilson (2005) emphasize the importance of having an outsourcing strategy that is in line with the overall cooperate strategy. This is supported by Kulkarni and Jenamani (2008) who further propose that the make-or-buy decision should be conducted in a structured manner. They, thus, determine that the strategic direction of the firm needs to be set before any decision regarding whether to make or buy could be taken (ibid). In order to do so, it is important to consider the corporate performance measures as well as corporate goals (ibid). McIvor (2000) support this and highlight that outsourcing should be the result of a strategic decision and that the made decision should be integrated into the overall business strategy.

3.4.2 Core competence
According to Quinn and Hilmer (1995), it is highly significant for a firm to identify which internal activities that create customer value in order to establish a successfully outsourcing strategy. Further, they argue that all other activities, which are not core competence, should be performed by an external supplier in order to achieve competitive advantage (ibid.). Kumar et al (2010) state that the first step a firm needs to take, when facing an outsourcing decision, is to investigate whether the activity is a core competence or not. Moreover, outsourcing of an activity that is related to the organization’s core competence will lead to devastating effects, as these competencies are the root of the firm’s sustainable competitive advantages (ibid.).

Definition of core competence
Dolgui and Proth (2013) define core competence as “the collective knowledge of the production system concerned, in particular knowledge of procedures and how to best integrate and optimize them”. In other words, they describe these competences as the activities that make the firm able to stay ahead of its competitors (ibid.). Walsh and Linton (2001) support this and add further that a core competence provides potential access to a wide range of market and industries. Additionally, Walsh and Linton (2001) opine that a core competence is hard to imitate by competitors. Several authors are referring to Quinn and Hilmer’s (1995) wider definition when speaking of core competences. They suggest that, for a firm activity to be accounted as a core competence, there are several criteria that need to be achieved.

First of all, a core competence is a cross-functional knowledge set or skill that generates sustainable competitive advantages for the firm. In more detail, they opine that a product or function too easily can be imitated by a competitor or be replaced by a substitute and therefore cannot be classified as a core competence. Secondly, Quinn and Hilmer (1995) describe core competences as flexible platforms that, in a long term perspective, are capable of adoption or evolution. To be able to create flexible skills, in areas that customers will value over time, and regularly reassess the market demand is therefore a prerequisite of such platforms. As a third criteria, Quinn and Hilmer (1995) limit core competences to be few, more commonly two or three, in numbers. They state that, as work become more complex it requires intense managers’ attention and dedication, which prevent firms from being able to perform superiorly and achieve effective management at every single activity in the value chain. Moreover, Quinn and Hilmer (1995) clarify that a core competence is a unique source of leverage in the value chain, as well
as an aspect that is important for the customers in the long run. Furthermore, in order to be able to perform some activities more effectively than competitors, focus in selected areas where the company can dominate is a prerequisite. Finally, in order to be categorized as a core competence it has to be embedded in the organization’s system, thus sustainable competencies cannot depend on a single talented star within the organization. As the authors state, “the firm must convert these competencies into a corporate reputation or culture that outlive the stars”. Hilmer and Quinn’s (1995) definition of core competence are summarized in figure 7 above.

In order to identify core activities, Arnold (2000) divides a company’s activities into four separated categories, namely the company core, core-close activities, core-distinct activities and disposable activities. The company core activities are described as being closely connected to the existence of the organization. Further, the close-core activities are linked with the core activities and can be considered as indirect company core. Finally, the core-distinct activities could be regarded as support activities and the disposable activities are generally available for everyone at the market. Arnold’s (2000) division of a company’s activities is illustrated in figure 8 to the left.

Walsh and Linton (2001) further state that core competence is a relative and, hence, temporal measure and present a systematic method for identification of company core activities. To start with, this process aims to identify the internal technological competences and the associated managerial capabilities at the company. These are both sources of the firm’s competitive advantages, according to Walsh and Linton (2001), and therefore need to be taken into consideration when a firm wants to evaluate its core competences. Apart from above mentioned authors, Walsh and Linton (2001) stress the importance of investigating the competitors and the specific industry when identifying a firm’s core competences. This is reflected in the next steps, which includes identification of the competitors’ competences and capabilities. Finally, the market should be examined so that necessary competences and capabilities that are needed, in order to reach the industry standard and customer demand, could be determined. The identification of competences that provide value for the customer in a specific market environment is a fundamental step in the process of identifying a firm’s core competences according to Walsh and Linton (2001). Furthermore, Walsh and Linton (2001) state that it is the connections between the technological competences and managerial capabilities, that are of value across multiple industries and functions, that generate core competences.

The identification of technical competences and managerial capabilities, that is necessary in order to succeed in the specific industry, is executed by investigation of the considered company’s standard operations, forecasts for the industry, industry publications and through interviews with industry experts, according to Walsh and Linton (2001). Thereafter, managers at the firm which is under investigation, or industry experts, rate the importance of the identified competences, with the associated managerial capabilities, by using a five-point Likert scale. The highly rated competences are thereafter categorized into one of the four competence groups; material competences, fabrication and assembly competences, knowledge-based competences and finally, knowledge-embedded competences. All these competence categories have a respective managerial capability that include processes and routines which enable the firm to manage the competences and are crucial in order to gain competitive advantages. Thereafter, managers at the firm rate the firm’s performance regarding the conducted list of competences and capabilities. Similarly, the firm’s stakeholders, and industry experts, are asked to execute a survey and rate the existence and quality of the firm’s performance considering these competences and capabilities. Walsh and Linton (2001) finally suggest an equally investigation of the competitors competences and capabilities. (Walsh and Linton, 2001)
**Core competence and outsourcing**

It is essential for an organization to maintain its advantage towards its competitors within its selected core competence according to Quinn and Hilmer (1995). This includes keeping the core activities in-house to avoid the risk that external parts get access to critical knowledge, which the organization’s competitive advantages rely on (ibid.). Further, van Weele (2012) states that, given that the supplier markets are entirely reliable and effective, all other activities should be outsourced. However, the markets consist of many inbound inefficiencies, opportunism and uncertainties, why this is not a viable strategy according to Ellram and Billington (2001). To keep all activities in-house is seldom an efficient approach stated by Abrahamsson et al (2003), as the support activities solely gives a marginally contribution to the firms profit and yet occupy a significant part of management time and effort.

Arnold (2000) discusses the degree of internal manufacturing and further means that this is closely connected to the outsourcing object, from an industrial perspective. It is concluded that in the long run the optimal outsourcing strategy, when considering both core competence and transaction cost economics, seems to be to de-materialize the company entirely and not even process the final assembly line internally (ibid.). As a result of this, the company will act as a supplier and customer management and the only value chain activities that should be left in-house are purchasing and marketing, according to Arnold (2000).

However, Abrahamsson et al (2003) state that it is not an easy task to determine which internal activities that are core competence, and which are not. Nevertheless, it is vital to establish an internal definition of what is considered to be core competences according to McIvor (2000). Mistakes in the core competence identification process can cause outsourcing of a firm’s competitive advantages, stated by Harland et al (2005), who further opine that the decision regarding how close to core outsourcing should be is difficult to make. Abrahamsson et al (2003) additionally declare that some activities can be both strategic and critical for a company’s business, but still not account as a core competence. There is also a need to investigate existing couplings between activities to fully understand what impact outsourcing of one of them will have on the remaining business. To outsource a supporting close-core activity can cause significant obstacles for the core activity, and there is always a risk in defining the core competence too narrowly. Further, it is not obvious what is considered as the firms’ core competence in a couple of years from now. It is also hard to say what knowledge that is required in a long term perspective, concerning the development of a company’s core competence (ibid.). According to these statements, Abrahamsson et al (2003) assert that the decision whether to make internally or to buy from an external supplier needs to be based upon a well-balanced strategic resolution.

### 3.5 Opportunities with outsourcing

Brown and Wilson (2005) state that there are numerous benefits with the outsourcing concept, including cost reduction, increased focus, improved image of the firm, increased sales opportunities, reduction of customer dissatisfaction and to make time and resources available. Further, the reasons for outsourcing range from both tactical to more strategic, according to van Weele (2010). The tactical reasons include the ability to minimize control and production costs, liberate capital and internal resources and improve the financial result (ibid.). Brown and Wilson (2005) support this and argue that these tactical reasons are often tied to a particular problem at the firm, and that outsourcing is seen as a direct solution to this. The strategic reasons, however, include improving the company’s focus and flexibility, access of knowledge and the ability to reduce risks by sharing them (van Weele, 2010). The strategic level of outsourcing provide firms with greater value in a long term perspective, as stated by Brown and Wilson (2005), and the relationship between the buyer and supplier develops with the objective to achieve mutual benefit. In addition, Brown and Wilson (2005) describe a third level of outsourcing, namely transformational outsourcing. Here, outsourcing is used as a tool to redefine business and is perceived as a force for changes useful in firms’ strive for increased market share (ibid.).
Below, some of the most common advantages of outsourcing are presented in more detail. In addition, factors that are affected by the outsourcing decision and which SED has a special interest in are described as well. These are: access of knowledge and resources, increased flexibility, improved efficiency, lead times and the opportunity to achieve higher quality of the products or services. Moreover, there is an opportunity to decrease both costs and risks, which will be discussed further on.

3.5.1 Access of knowledge and resources

Strategic outsourcing decisions are characterized by being capability and competence intensive and are focused on acquiring expertise, knowledge, processes and capabilities found externally. The aim with these strategically driven outsourcing decisions is not only to help operations but also contribute to the strategic and competitive advantage of the organization. Furthermore, these efforts often include collaborations between the outsourcing company and multiple suppliers, with the intention of getting the best assortment of knowledge and expertise. (Power et al, 2006)

Definition of knowledge and resources

In the article Knowledge Management in Outsourcing Environment: People Empowering People by Christopher and Tanwar (2012), a distinction is made between three different types of knowledge. The first type is core knowledge which refers to the basic level of knowledge required by all members in a particular industry. This knowledge is a demand in order to simply be able to function and does not provide a good basis for competitiveness. The second type of knowledge, however, is referred to as advanced knowledge and works as a competitive edge for companies. By either knowing more than competitors, or better applying the knowledge, this type of knowledge sets a good foundation for a competitive advantage. Lastly, innovation knowledge represents a significant differentiating factor from other companies and enables companies to be market leaders. (Christopher and Tanwar, 2012)

Moreover, Richnér and Rognes (2013) distinguish between the creation, transfer and retention of knowledge. Creation of knowledge refers to when new knowledge is generated while transfer of knowledge is the process where a unit is affected by another unit’s experience. Finally, retention of knowledge refers to the process of storing knowledge, so that it can be sustained for a longer period. Richnér and Rognes (2013) also discuss the difference between tacit and explicit knowledge, and state that both types are necessary in an organization. Tacit knowledge refers to knowledge that is rooted in the personnel’s experiences and values while explicit knowledge is embedded in the organization and not dependent on single individuals. Explicit knowledge is thus easier to transfer between individuals and organizations.

Furthermore, Golder et al (2012) define resources as “material and human resources used to generate produced attributes”. The authors further specify that material resources include raw materials and offerings provided by the employees of the firm. Human resources, however, refer to physical labor as well as expertise and insights provided by employees and suppliers. Olavrieta and Ellinger (1997), however, provide a slightly differing view of a firm’s resources by classifying them into the three categories input factors, assets and capabilities. Input factors are further described as elementary and readily available while assets regard more rare and valuable resources that are owned and controlled by the company. Finally, firm’s capabilities are defined as knowledge based resources that create complex bundles of individual skills and assets. The authors also make a further distinction by clarifying that if any of the firm’s resources are valuable, rare as well as hard to imitate, than it is a strategic resource.

Access of knowledge and resources and outsourcing

One motive for outsourcing is that it enables the access of knowledge and resources, without having to own the assets (Powel et al, 2006). It is not economically advantageous for a company to be self-sufficient, as there are other companies who can utilize resources better and supply them to a lower cost (ibid). Additionally, external suppliers may in fact be superior at supplying the resources to a better cost and quality than is possible in-house (ibid). Hence, a common motive for outsourcing is to gain access to
specific knowledge, skills or techniques that are desired (ibid). According to Chang and Garbaxini (2012), however, the magnitude of the gains a company will receive when outsourcing, depend on its capacity to absorb knowledge and thus the company’s capabilities.

An additional advantage is that outsourcing also enables access of specific assets that the outsourcing company otherwise would have to invest in (Powel et al, 2006). Brown and Wilson (2005) agree on this and further emphasize that if an organization lack the required skills to successfully perform a task or an activity, outsourcing is a good alternative. Another motive for outsourcing is that it increases the capacity of the outsourcing company (Malmgren, 2010). Assid et al (2015) agree and further emphasize that in order to meet an increased customer demand, many companies have outsourced part of their production. By gaining access to the supplier’s manufacturing resources a higher capacity could thus be obtained (ibid).

Moreover, it is important to recognize that outsourcing not only enables access of knowledge and resources but that it also invokes a risk for loss of knowledge. In specific, tacit knowledge is often lost, or at least not transferred, when an activity or service is outsourced to an external supplier. The reason for this is that tacit knowledge often is linked to individual personnel and is hard to both identify and fully specify. In addition to this, when outsourcing, it is often desirable to adapt a new production strategy or method and hence there is little interest in the old procedures and the associated knowledge. The risk with this, however, is that important knowledge that is in fact vital for superior performance might be overlooked and lost. (Ritchnér and Rognes, 2013)

3.5.2 Flexibility

Flexibility is recognized as a key factor in order to achieve competitive advantage in today’s dynamic and volatile business environment (Scherrer-Rathje et al, 2014). Tan and Sia (2006) agree with this statement and further emphasize that “flexibility is increasingly becoming a strategic imperative for business survival”.

**Definition of flexibility**

According to Arias-Aranda et al (2011), “operations flexibility reduces firms’ vulnerability to unexpected alterations in short-term issues such as product and/or service volume, timings, or schedules as well as long-term concerns such as variations in customer’s needs or fast obsolesce of technology”. Scherrer-Rathje et al (2014) further define flexibility as “the ability to change or react with little penalty in time, effort, cost or performance”.

Furthermore, Tan and Sia (2006) divide flexibility into the four dimensions; modifiability, robustness, new capability and ease of exit. The first dimension of flexibility, modifiability, refers to the ability of an organization to make modifications, such as alterations in the products or services that are provided, to cope with less foreseeable events. Moreover, the dimension robustness is defined as the ability to withstand alterations in the external environment, such as uncertain and varying demand, product mix and available resources. The third dimension of flexibility, new capability, addresses radical changes in the external environment which demand an innovative response and transformation of the existing organization. Finally, ease of exit, refers to how fix the outsourcing relationship is and whether it allows transfer of products and services to other vendors or to the internal production. Scherrer-Rathje et al (2014) contribute to the discussion of flexibility by emphasizing that manufacturing flexibility can be divided in the four types; product, mix, volume and labor competence flexibility. Product, mix and volume refer to the ability to offer new products as well as to be able to change the offered product assortment and volume. These aspects are thus included in the dimensions that Tan and Sia (2006) discuss. Labor competence flexibility, however, refers to the ability of the workforce to deal with technology-driven additions and subtractions from products and thus provide a new perspective of flexibility that needs to be taken into consideration.
Flexibility and outsourcing

One of the possible strategies for attaining a flexible manufacturing process, and the ability to quickly react to customer requirements, is outsourcing. However, there are mixed opinions of whether outsourcing really results in increased flexibility or not and what effect outsourcing have on flexibility depend on characteristic of both the outsourcing company and the supplier. (Scherrer-Rathje et al, 2014)

Abrahamsson et al (2003) state that outsourcing can result in a higher strategic flexibility, as the outsourcing company can avoid investments in new technologies or physical structures. By reducing the number of investments, the outsourcing company can lower its costs by only paying for the capacity that is ordered from the supplier. Thus, the outsourcing company can attain more free capital and lower its risk, which results in a higher degree of flexibility. Another aspect that Quinn and Himler (1995) discuss is that outsourcing provides the buyer with higher flexibility by reducing the company’s design-cycle times.

In the article Manufacturing flexibility through outsourcing: effects of contingencies, Scherrer-Rathje et al (2014) conclude that the effects of outsourcing depend on the factors asset specificity, economies of scale and scope, organizational learning and dynamic capabilities. They argue that an outsourcing company can benefit from gaining access to a supplier’s economies of scale and scope, which will result in increased volume flexibility. Tan and Sia (2006) contribute to the discussion by stating that it is hard to use the vendor’s generic capability, and economies of scale, if the outsourced service is highly customized. The authors hence state that minimizing customization is an important tool for improving flexibility, as limited specialization reduces the extent to which the market exchange is personalized. Furthermore, Scherrer-Rathje et al (2014) state that high asset specificity can have a negative effect on mix flexibility when outsourcing, as the supplier will need to make investments in order to fulfill the requirements of the outsourcing company. Tan and Sia (2006) agree on this and further add that the processes that are best suited for outsourcing are the processes on top of the maturity spectrum as these are understood well enough to be standardized and, thus, more easily adapt to other processes and external partners.

In addition to this, whether access of the supplier’s economies of scale will result in increased volume flexibility or not depends on the relationship between the outsourcing company and the supplier, according to Scherrer-Rathje et al (2014). In more detail, whether the outsourcing company needs to compete with other customers for the supplier’s capacity or not also affects the level of volume flexibility that can be achieved. Tan and Sia (2006) hence promote the strategy foster partnership quality, which includes the creation of mutual trust and shared values within the outsourcing relationship, in order to establish an advantageous relationship with the supplier. The authors further stress that a strong partnership is an important factor in order to nourish flexibility and quickly be able to adapt to unexpected changes in the external environment.

Furthermore, when a company outsources a large part of its requirements, it can lose the ability to manufacture the product in-house which will lower the labor competence flexibility, according to Schereer-Rathje et al (2014). The authors therefore emphasize the importance of paying careful attention, to avoid loss of knowledge. They also stress the need to strive to access additional knowledge trough the supplier by encouraging organizational learning. Tan and Sia agree (2006) on the importance of maintaining in-house competence in order to avoid significant flexibility pitfalls when outsourcing. They hence suggest that a team that can perform tasks similar to the outsourced should be maintained in-house, in order to keep in top of the technology. Another aspect that Tan and Sia (2006) discuss is that the
in-house competence also can be strategically important in order to cope with varying demand and to bring the processes in-house, if the outsourcing vendor is unwilling to adapt to required changes.

Finally, Tan and Sia (2006) also promote the strategy proactive sensing which refers to the ability to search for meaningful signals or trends in the business environment in order to foresee required changes and hence become more flexible. By scanning the competitive landscape of vendors, the organization can strengthen their negotiation power and nurture continuous innovation in outsourcing. Similarly, Schereer-Rathje et al (2014) state that dynamic capabilities, which is a measure of a company’s ability to constantly renew, integrate, reconfigure and recreate existing processes, capabilities and resources in response to changes in the business environment, is important in order to achieve a high degree of flexibility when outsourcing.

3.5.3 Efficiency

In the article A Conceptual Framework for Understanding the Outsourcing Decision, Vining and Globerman (1999) state that many corporations outsource in the pursuit of higher efficiency. In addition to this, Chang and Gurbaxani (2012) state that the success of outsourcing highly depends on the efficiency of the outsourcing company. Furthermore, efficiency refers to making things in the right way, in order to achieve low costs per produced unit according to Olhager (2000).

Definition of efficiency

According to Business Dictionary (2015), efficiency is defined as “the comparison of what is actually produced or performed with what can be achieved with the same consumption of resources”. OECD (2015) describe efficiency as “the degree to which a production process reflects best practice”. Further, productivity is the determinant of efficiency and is most commonly defined as the ratio between the production output and input (ibid.). Traditionally, capital, labor, material and energy are considered as input factors in order to measure efficiency, stated by Heshmati (2003), where capital is the factor which is most difficult to quantify accurate. As output, the produced products are accounted either in physical quantity or in monetary values (ibid.).

Efficiency and outsourcing

López (2014) argues that firms outsource with the objective to increase flexibility and efficiency. Further, in his study Productivity Growth, efficiency and outsourcing in manufacturing and service industries, Heshmati (2003) shows that there is a correlation between increased manufacturing efficiency and the degree of outsourcing. In addition, he states that this is mainly an effect of the lowered labor costs that firms may benefit from when outsourcing (ibid.). Bakhtiari (2015) further argues that there is an immediate productivity improvement for the organizations that decide to outsource, especially for firms that prior to the outsourcing had a poorly productivity performance. On the other hand, firms which initially have efficient operations need to sacrifice some of the existing productivity in the short term perspective to acquire long term competitive advantages with the outsourcing approach, according to Bakhtiari (2015). In these cases, productivity improvements and cost cutting are not the reasons why outsourcing is executed. Instead, the intention commonly is to increase focus on research and development, innovation and exports (ibid.).

3.5.4 The time aspect

When configuring the supply chain, an important aspect to consider is how the lead time throughout the chain is affected, according to Li and Womer (2012). Furthermore, lead time is an important element that constitutes the definition of delivery service together with the other elements, delivery precision, customization and flexibility, delivery dependability, stock availability and, lastly, information (Oskarsson et al, 2013). Moreover, when making significant corporate decisions, numerous aspects of time need to be taken into consideration (ibid.).
Theoretical framework

Definition of lead time
According to Oskarsson et al. (2013), lead time can be defined as the time from when a customer makes an order until the order is delivered. The authors elaborate on this statement and add that in some instances it is very important for the customer to receive the order quickly, why lead time is relevant to consider. Moreover, the total lead time from when a customer makes an order until the order is delivered, is often built up by sub-lead times for each of the respective processes that take place in order to deliver the order. In particular, Oskarsson et al. (2013) state that a distinction is usually made between the lead time and the time it takes for a product or article to pass a certain step or production line, here defined as throughput time. Thus, depending on how the different lead times are defined and measured, the total lead time is usually the sum of several separate lead times for sub-processes.

The time aspect and outsourcing
According to Kulkarni and Jenamani (2008), when facing an outsourcing decision, it is necessary to take lead time into consideration. By outsourcing, a company’s design-cycle time can be reduced as multiple best in class vendors work simultaneously on individual components (Quinn and Himler, 1995). Specifically, a shorter design-cycle time can be achieved when purchasing rapidly developing products, fashion goods or complex systems. The reason for this is that each individual supplier has more in depth knowledge and better technology in the respective areas than an individual company could achieve alone (ibid).

3.5.5 Quality
According to Srivastav et al. (2012) there has been a trend from outsourcing of routine services to more complex and knowledge intense high end tasks, which have resulted in increased difficulty to define and measure the quality of the outsourced service. Seyedhosseini et al. (2012) further stress the importance of high supplier quality by stating that what makes customers highly satisfied is the quality they perceive from the products or services that they consume. Hence, achieving high quality, and quality enhancement processes, is necessary for organizations in order to achieve a sustainable advantage (ibid).

Definition of quality
In the article Defining quality, alternatives and implications written by Reeves and Bednar (1994), it is concluded that quality is a very broad and complex concept. Among many definitions quality can be defined as a measure of excellence, value, conformance to specifications and how well customer expectations are met or exceeded (ibid.). The authors thus state that it is hard to use a single, global, definition that fully entails all the components and aspects of quality. After analyzing different definitions Reeves and Bednar (1994) finally conclude that different definitions of quality are appropriate in different circumstances, and that a global definition would be of little use. Golder et al. (2012) agree on this and state that quality indeed is a complex component that lacks a common understanding across different disciplines.

Quality and outsourcing
What effect outsourcing has on quality is highly dependent on the specific supplier, the outsourcing company and the component or process that is outsourced. One of the challenges when outsourcing, is to create a mutual understanding of the specific demands on quality, and how this can be ensured on a day-to-day basis in every level of the process. In order to meet these demands, one method is to implement a quality process, which can be described as a series of reviews and verification actions needed to assure an expected result. (Setterwall, 2013)

According to Chou et al. (2011), a high quality outsourcing process should consist of the three steps integration, cooperation and coordination. Integration refers to the process of harmoniously structuring various attributes into other’s existing structure and procedures. The authors further define cooperation as the ability to work together in order to achieve mutual benefits and coordination as the process of accomplishing interdependence between entities. Furthermore, Chou et al. (2011) state that quality
assessment tools are important in order to achieve high quality when outsourcing. Six Sigma, ISO standards and Capability Maturity Model are examples of some commonly used methods that are often adopted by outsourcing companies in order to certify the quality of the outsourced service.

Furthermore, according to van Weele (2010) is has become more common to quality ensure the supplier instead of quality ensuring the respective articles. The reason for this is that it can be very costly and time-demanding to control each article and thus a more efficient method is to ensure that the supplier’s production process is quality ensured. This include writing detailed purchasing specifications, agreements on how to handle quality tests at the supplier and implementing processes for regular verifications. (van Weele, 2010)

3.6 The risks of outsourcing

When making an outsourcing decision, it is important to not only consider the expected advantages but also fully recognize the risks that are associated with the decision. Furthermore, each respective outsourcing decision involves different degrees of commitment and integration between the supplier and the outsourcing company, which leads to different risk concerns. Every outsourcing decision should thus be associated with a comprehensive risk analysis that is adapted to the specific situation. (Lee et al, 2012)

Definition of risk

According to Lockamy and McCormack (2010), risk is “a concept that has applications in everything we do”. They further specify that risk entail many aspects such as the lack of knowledge of impacting events and how to manage them. In order to define risk in the supply chain, Lockamy and McCormack (2010) classify it into the three categories: operational, network and external risk. Operational risk refers to the risk of loss due to inadequate internal processes and circumstances, or from external events. Network risk however, regard risks that are associated with the structure and other parties of the supply chain. Finally, external risk is defined as risks that are driven by external forces such as political, weather and market forces.

Aron et al (2005) further specify four types of risks that are associated with outsourcing, namely strategic, operational, atrophy and location risks. Strategic risks refer to the risks that at least one of the parties acts with opportunistic behaviour and deliberately tries to exploit the other party. Furthermore, the authors use the term operational risks in order to describe risks that are caused by unintentional breakdowns or limitations in the vendor’s operations. Atrophy risk is not caused by the vendor but is a long-term and intrinsic risk that occurs from the outsourcing itself. This risk includes loss of knowledge or competence at the outsourcing company, due to outsourcing of an activity or process. In order to facilitate the understanding of this master thesis, this risk is further on referred to as the risk of losing knowledge. Finally, Aron et al (2005) define location risk as risks that occur simply by moving an activity to a remote location. This risk also includes geopolitical and sovereign risks.

Das and Teng (2011) discuss different types of risks and how to control them. They clarify that perceived risk is differentiated from uncertainty as risk perception usually relates to the estimated probabilities of several outcomes. Moreover, they distinguish between the two types of perceived risk, namely relational risk and performance risk. Relational risk is defined as the probability and consequence of not having satisfactory corporation and arises due to the potential of opportunistic behaviour. Performance risk, on the other hand, refers to the many other factors that can affect the business collaboration. Intensified rivalry, varying demand, government policies and lack of competence of the partner firm are all examples of factors that account for performance risk. Furthermore, Das and Teng (2011) describe that these perceived risks depend on the two factors trust and control. In more detail, the trust aspect can be divided into the two types goodwill trust and competence trust, where goodwill trust describe if a firm has good intentions and acts in good faith within its business relations. Competence trust, on the other hand, defines what competence and capabilities that exists at the firm and hence if the objectives of the
Theoretical framework

Business collaboration are likely to be fulfilled according to this aspect. Moreover, the control aspect can be further divided into the three types behaviour control, output control and social control, according to Das and Teng (2011). Behaviour control pertains to in what extent the processes and activities that translate behaviour to result can be affected. Output control concerns in what degree the firm can control and measure the generated result in an objective way and finally, social control define the possibility to influence the business partner in areas such as objectives, visions and core values, according to Das and Teng (2011).

According to van Weele (2010), a thorough risk evaluating analysis needs to be executed prior to the make-or-buy decision. In order to do this, there are several different risk assessing techniques to choose between and Luko (2014) present a list with over 30 different methods at different complexity levels. One of the most general ways of measuring risks, according to Ball and Watt (2013) and van Weele (2010) among others, is by first identifying the hazards followed by an assessment of its likelihood and the potential severity of its consequences. This commonly is presented in a 5 x 5 matrix, see figure 9 below, with the likelihood ranging from rare to almost certain and the consequences spanning from insignificant to severe (ibid.). The likelihood and consequence score can, according to Fang and Marle (2013), be obtained by either a qualitative or quantitative assessing approach. By multiplying the likelihood score and the consequence score, the risk factor is acquired. The higher risk factor, the more critical the risk is and, consequently, reduction of these risks should be prioritized, according to van Weele (2010).

Figure 9: Risk assessment

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>(1) Insignificant</th>
<th>(2) Minor</th>
<th>(3) Moderate</th>
<th>(4) Major</th>
<th>(5) Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Rare</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>(2) Unlikely</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>(3) Possible</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>(4) Likely</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>(5) Almost certain</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

As stated by Ball and Watt (2013), this measurement method is commonly used because of its simplicity and transparency. However, there are some drawbacks of using this method (ibid.). Firstly, the risk factors that are generated are dependent on the assessor which may lead to different ratings to the same risk and a non-objective result. In more detail, personality, worldviews, culture, psychosocial factors, personal experience and education are some of the aspects that may affect the assessment when this method is practiced, according to Ball and Watt (2013). Levine (2012) suggests that by usage of logarithmically scaled axes, this bias problematic can be reduced. The reason for this is that a larger change in the scoring of likelihood and consequence is necessary in order to generate a contiguous risk factor (ibid.).

Fang and Marle (2013) add to this risk assessment discussion that there might exist linkages and interrelations between different risks that creates risk networks or risk loops which need to be taken into consideration when evaluating risks in a complex setting. This can, according to Fang and Marle (2013), be illustrated by using a risk structure matrix (RSM), see figure 10 and 11 below, where \( RSM_{ij} = 1 \) when the risk \( R_j \) have an impact on the risk \( R_i \). By utilize this method, no concerns about the likelihood and consequence of the risk is addressed, why it should be used as a complementary to the classical risk matrix which was previous presented (ibid). This provides the assessor with new insights into risks and new risks, supplemental to the classical method, may be identified as key elements in the risk assessment process, according to Fang and Marle (2013).
There are several techniques which aim to facilitate the risk calculation and likelihood assessment processes, and in appendix 1 a list of suggested methods can be found. Luko (2014) presents three general approaches when estimating probability. Firstly, the usage of relevant empirical data or actual observations is stressed (ibid.). Secondly, Luko (2014) recommends the usage of well proven estimating methods or simulation techniques in order to generate the likelihood forecasts. Furthermore, expert opinion can be used as guidance when estimating the probability (ibid.). Fault tree analysis (FTA) is one method which makes it possible to perform a quantitative measurement of the probability of a specific risk in a large and complex setting, according to Luko (2014). In more detail, the method means to decompose the considered risk into several events that may cause the considered top event or risk, according to Krus (2012). In that way, the probability of the top event or risk can be quantitatively measured based on the probability of individual root events (ibid.). In order to evaluate the probability of the top event or risk, all root events and their relations to each other are taken into consideration, as stated by Krus (2012). If all individual root events need to occur in order for the top event to occur, than the probability of the root events are multiplied, in line with the risk R1 illustrated in figure 12 below (ibid.). Further, according to Krus (2012), if just one of the root events is able to cause the top event or risk, then the probabilities of the root events are or added with each other, as visualized as the risk R2 in figure 12 below.

**Figure 12**: Illustration of a single branched fault tree analysis (FTA). Risk 1, R1, refers to a risk where all root events need to occur in order for R1 to occur. Risk 2, R2 refers to a risk where one single root event can cause the risk.

Risk and outsourcing

According to Abrahamsson et al (2003), there are many risks, both strategic and operative, that are related to outsourcing and some are hard to detect before they occur. Further, if outsourcing is implemented by wrong reasons, or in the wrong way or time, it could lead to unnecessary risks and...
pitfalls (ibid.). Furthermore, the risks can be divided in the following categories: too dependent on supplier, imitation and minimized competitive advantage, loss of core competence, loss of value enhancing processes and limited ability to transform which may result in double costs (ibid.). The risk of becoming too dependent on suppliers can occur for many reasons, such as lack of other suppliers on the market, insufficient contract competence and the need of specific resources or services (ibid.). When outsourcing there is thus a risk of getting too dependent, which can result in opportunistic behaviour by the supplier as stated by Abrahamsson et al (2003). One way to minimize this risk is to adopt multiple vendors (Lee et al, 2012). Another risk is that the outsourcing company’s competence and competitive advantage decrease as a result of imitation by competitors, according to Abrahamsson et al (2003). In particular, there is a risk of imitation if the supplier is responsible for product development and design (ibid.). Lee et al (2012) agree on this and state that in a supply chain, with the sharing of leading edge technology, there is always a risk of losing the competitive advantage to competitors.

Furthermore, Abrahamsson et al (2003) argue that when outsourcing it is hard to correctly deduce what a company’s core competence is, especially in the long term, and hence there is a risk of unintentionally transferring activities or functions that are part of, or closely related to the core competence. In addition, if too many activities are outsourced, the company face the risk of having too little value adding activities, which will make it hard to generate a steady income. Yet another risk is that the outsourcing company lack the ability to adapt to the changes and implement internal changes in response to the outsourced service, which will result in unnecessary costs. (Abrahamsson et al, 2003)

In the dissertation, Managing Risks in Business Critical Outsourcing – A Perspective from the Outsourcer and the Supplier, Malmgren (2010) identifies a range of risks when outsourcing. Apart from the risks that Abrahamsson et al (2003) discuss, additional risks are decrease in quality, legal problems, loss of control and low adaption of new technology by the supplier. Furthermore, there is also a risk that the supplier does not know the business of the company, which may result in decreased customer satisfaction. Moreover, van Weele (2010) add a new perspective by stating that outsourcing in fact could be a strategy to minimize existing risks, by sharing them with external suppliers.

3.7 The costs of outsourcing

Vining and Globerman (1999) identify three types of costs that are important to consider in the outsourcing decision. The first type of cost is production cost, which refers to either the product price or the cost of internal production (ibid.). The other two costs, bargaining and opportunistic costs are commonly referred to as costs of governance or transactions costs, as stated by Vining and Globerman (1999). These include negotiation costs, monitoring of the outsourcing agreement and costs associated with writing and updating the business contract (ibid.). Shah (2007) agrees upon this and add that the transaction cost includes the cost of source selection, performance management and dispute resolution as well. Bargain costs arise when both parties act in good faith, while opportunistic costs arise when at least on party acts with self-interest and in bad faith according to Vining and Globerman (1999).

3.7.1 Production cost and total cost analysis

Production costs may be lower when outsourcing compared to internal production due to several of reasons. Firstly, in-house production is often conducted at a level that is too low to be fully efficient and economically advantageous. This especially concern products or services where the companies have low unit demand. When outsourcing, however, the external supplier usually have several of customers, and a higher production volume, which enables them to achieve economies of scale. Secondly, there is a tendency for internal production units to act like monopolists which may result in lower efficiency. The main reason for this is that internal units lack strong incentives due to the lack of competition, in contrast to external suppliers. Furthermore, companies may experience inefficiencies in their production due to focusing on too many activities. Hence, it may be advantageous to outsource some activities to be able to better focus on a few, core, activities. Finally, in some instances parts of the internal production may
cause negative externalities in the organization, due to different cultures or motives. (Vining and Globerman, 1999)

Oskarsson et al (2013) stress that when a firm faces a change within its logistic structure, it will most certainly affect costs in the entire organization, not only the departments which are obviously related to the change. Lambert et al (1998) agree upon this and further state that if cost reduction efforts focusing on one single area in isolation from its system, reduction of one cost may increase costs in another area of the logistics system. Therefore, it is vital to use a measure approach which captures all costs affected by a specific decision in order to determine the actual cost of the change (Oskarsson et al, 2013). Ellram and Maltz (1995) agree upon this and further suggest the use of a process flow diagram that covers all activities affected by the change. Furthermore, this approach facilitates a comparison between the make versus buy scenario according to Ellram and Maltz (1995). Oskarsson et al (2013) suggest total cost analysis as a suitable tool when a change is about to be implemented and this is further supported by Lambert et al (1998) who express that the total cost concept is the key to effectively manage logistics processes. Moreover, this approach is useful when comparing a scenario before and after the change, in order to determine which of the alternative setups that generate the lowest total cost, according to Oskarsson et al (2013). Ellram and Maltz (1995) support the total cost analysis approach and state that an accurate cost evaluation process is essential in order to make a successful make-or-buy decision.

Oskarsson et al (2013) recommend that the total cost analysis include the cost parameters; inventory carrying costs, warehousing costs, transportation costs, administrative costs and additional logistic costs. The inventory carrying costs include costs related to capital tied up and costs of risks, such as obsolescence, wastage and scrap of products stored. Further, the warehousing costs constitute of the warehousing operational costs, including costs of labor, material handling as well as building and assets associated to the warehouse. All costs associated with transportation, including administration of shipping and receiving goods, are categorized as transportation costs. Further, all other administration costs that are affected by the change represent an additional standalone cost parameter. Finally, Oskarsson et al (2013) suggest that the cost parameter additional logistic costs should include information costs connected to the material flow, costs of package, material costs as well as other costs related to the management of the firm’s logistic operations.

Ellram and Maltz (1995) divide the total cost differently, when considering outsourcing. In more detail, they suggest a number of activities, namely management, delivery, service, communication, price and quality, that contribute to the total cost and therefore should be considered. Moreover, what costs that should be included into the total cost analysis is, according to Oskarsson et al (2013), highly context dependent and the model used should advantageously be adapted to the current circumstances. Ellram and Maltz (1995) further state that, from an outsourcing decision perspective, only the costs that vary depending on the decision should be included into the cost analysis. Moreover, each make-or-buy decision should be seen as a standalone project and the analysis should therefore be uniquely evaluated (Ellram and Maltz, 1995).

McIvor (2000) supports that a carefully evaluated cost assessment is essential in order to be able to make a successful make-or-buy decision. Furthermore, this investigation needs to measure all cost associated with the decision and McIvor (2000) suggests activity based costing (ABC) as a suitable cost analysis method. This method focus upon the firm’s activities and it is assumed that all activities are performed with the aim to support the refinement of the firm’s products according to Gerdin (1994). Furthermore, in order to perform these activities, resources, such as employees, material and technology, are needed (ibid.). In other words, activities can be considered as processes that transform resources (input) into products (output), as described in figure 13 below. According to Gerdin (1994), the disadvantage of using a traditional cost analysis, instead of activity based costing, is that the overhead costs are allocated proportionally based on the products direct cost. Hence, unless the overhead in fact is proportional to the
direct cost, this will result in an unfair allocation. When using activity based costing, however, the overhead costs are allocated with the help of resources and activities, which enables a more accurate division of the overhead costs.

**Figure 13:** Activities consume resources and products consume activities in the activity based costing approach.

Moreover, in order to be able to calculate the total cost of a specific product, Gerdin (1994) states that the costs of the resources and activities need to be allocated. First, all activities are given a cost based on what resources and to what extent these are used by a specific activity according to Gerdin (1994). Some indirect costs can be directly linked to a specific activity, while others need to be allocated with the use of specific distribution keys (ibid.). Thereafter, the costs of an activity are allocated to the products which use the activity in proportion to the products’ claim on the activity according to Gerdin (1994).

### 3.7.2 Transaction costs

According to Vining and Globerman (1999), the cost of outsourcing consists of the cost for the bought item itself and the costs associated with the management of the outsourcing transaction. This is supported by Shah (2007) who further state that the transaction cost depends on how the outsourcing transaction is organized. Vining and Globerman (1999) identify three main factors that determine the extent of the costs associated to outsourcing. The first factor is product, or activity, complexity, which defines how difficult it is to specify and monitor the conditions and terms of a product (ibid.). Shah (2007) also states that the cost of a negotiation is dependent on the product and its service, as well as the internal activities of the organization associating with the product. The second factor is asset specify, which is a measure of how limited the use of an asset is, according to Vining and Globerman (1999). An asset is classified as specific if it is necessary in the production of a certain good, but has little alternative uses (ibid.). Finally, the third factor identified by Vining and Globerman (1999) is contestability which is a measure of how many potential providers of a product or service that is, or could be, available. Shah (2007) also discuss that the transaction cost depends on the prevailing market structure. In more specific, Shah (2007) states that the negotiating cost depend on if perfect competition occurs on the market or not. Furthermore, this factor could be viewed as an extension of asset specificity, as high assets specificity result in low contestability, according to Vining and Globerman (1999).

**Figure 14:** Vining and Globerman’s outsourcing matrix.

In order to illustrate how asset specificity and product complexity, and indirectly contestability, affect the outsourcing decision, Vining and Globerman (1999) present possible strategies. These strategies are illustrated in figure 14 to the left. The products corresponding to square 1, in figure 14, have high product complexity and low asset specificity. These products are associated with a high cost of governance due to the difficulty of writing fully specified contracts. Nevertheless, as asset specificity is low there are many potential suppliers and hence the risk of opportunistic behavior is low. Products in this square often apply to outsourcing of professional services or activities. Furthermore, square 2 consist of products with both high product complexity and asset specificity. Should the supplier hold the assets, there is a risk of them acting opportunistically due to the high product complexity. If the outsourcing company holds the assets, however, bargain costs are often high as it is difficult to specify the contract. (Vining and Globerman, 1999)
Products with both low complexity and low asset specificity, corresponding to square 3 in figure 14, are well suited for outsourcing as they offer potential for lower production costs and low costs of governance. Typically, products with these characteristics are standard products, services or activities. Low product complexity implies that product or service contracts easily can be specified. Similarly, low asset specificity implies that there are many potential suppliers and that inefficient or opportunistic behaving suppliers easily could be exchanged. Finally, products in square 4 have low product complexity and high asset specificity and hence, it is possible to write detailed specifications and contracts. The challenge with products with high asset specificity is that the supplier is vulnerable to opportunistic behavior by the outsourcing company, given that the supplier holds the assets. In order to avoid this, the outsourcing company can hold the assets and simply rent them to the supplier. The disadvantage with this, however, is that the outsourcing company needs to invest in the assets themselves, which has a negative impact on the transactional costs. (Vining and Globerman, 1999)

3.8 Decision model theory regarding outsourcing

In order to gain inputs into how a make-or-buy decision model can be constructed, this section aims to summarize some of the theoretical models that have been constructed by other authors. Beginning with Brandes (1994), he develops a fundamental model for the make-or-buy decision in the article Strategic changes in purchasing, two main tracks. In the model, the first step is to determine whether the investigated activity or component is a core competence. If the answer is no, the next step is to examine whether there are any significant risks connected to the buy scenario. Should the activity or component be considered as a core competence, however, it should not be transferred to an external supplier. Similarly, if there are any high risks with involving an external part, in-house production is preferable. Finally, if no is the answer to the first two questions a cost analysis should be performed in order to make a final assessment. Thus, if the cost associated with the decision is lower when producing in-house, this alternative should be chosen. (Brandes, 1994)

Furthermore, there are numerous additional authors who have developed similar frameworks or models in order to facilitate the make-or-buy decision. Firstly, Kumar et al (2010) present a more detailed model which is, similar to Brandes’ (1994) model, initiated by evaluating whether the investigated activity or component is a core competence. Thereafter, the internal capacity and knowledge is assessed and it is determined whether the need is long or short termed. Finally, the last step of the model consists of a cost analysis. Parallel to this internal investigation, Kumar et al (2010) suggest the execution of an external vendor assessment in order to determine if there are any potential and appropriate suppliers. Additionally, the authors stress the importance of regularly re-evaluation of the make-or-buy decision.

McIvor (2000) also contribute to the discussion by developing a model in order to aid the outsourcing decision. This step-by-step model is closely related to Brandes’ (1994) model but differ in the aspect that risk is not given a central part but, on the other hand, the supplier relationship is considered. McIvor (2010) further present an additional framework for determining whether to produce internally or externally. In this framework the contribution to the firm’s competitive advantage is investigated on one axis and the firm’s relative capability position is determined on the other axis. This creates four quadrants with respective prerequisites and McIvor propose suitable actions for each of the four scenarios.

Kulkarni and Jenamani (2008) develop an outsourcing decision model that includes 17 steps that are poorly explained how to use. Firstly, the model aim to establish whether the concerned activity or component is strategically important, which could be compared to the core competence aspect. Thereafter, an internal capacity assessment is performed followed by a benchmark evaluation. This benchmarking process is to determine whether in-house or supplier production is preferable according to the parameters cost, quality and effectiveness. Further, the model also takes risks and supplier competition into consideration.
McIvor (2000) further state that, when developing an outsourcing framework, it is significant to determine logical and sequential steps. Additionally, it is of high importance that how and why these steps should be used is explained (ibid.). Further, Kulkarni and Jenamani (2008) stress that, when developing a make-or-buy decision model, not only existing theories are of interest, but the model needs to be modified with regard to the contextual circumstances. Fill and Visser (2000) agree upon this and add that it is important to involve managers and employees in order to identify contextual internal and external factors.
4 Problem specification

This section aims to determine how the investigation process should be configured. In order to achieve this, firstly the considered process is clarified and thereafter, the research process is decomposed into concrete stages. In each of these stages specific research questions are formulated, which will act as a foundation when conducting the analytical study.

4.1 The considered process

Today, SED lacks a general process for the make-or-buy decision. Historically the decision has been the result of case specific analysis, rather than following a structured methodology. Thus, there is a need to adapt a structured and standardized decision process, which this investigation aims to develop. The make-or-buy decision model is focused on facilitating the evaluation of which purchasing level that is most advantageous. Furthermore, the start of the decision model is when the user has an idea of which purchase levels that are of interest to evaluate. By following the steps in the model, a decision of which of the evaluated purchasing levels and what make-or-buy setup that is most beneficial to the firm will be obtained. The implementation of the make-or-buy decision, however, is outside the scope of this investigation. Therefore, supplier selection and evaluation, which is part of the implementation, will not be discussed in detail.

4.2 Research process

In order to create a clear structure for this research, the purpose of this study needs to be further investigated. The aim is thus presented once again below:

The aim of this study is to, in line with Atlas Copco’s business strategy, develop a decision model in order to facilitate the make-or-buy decision at SED.

As stated in the purpose clarification, it is vital that the make-or-buy strategy is developed in accordance with Atlas Copco’s general business strategy. It is hence important that the decision model is based on both theoretical research and the firm’s production strategy. The first stage of this investigation is thus to conduct an initial analysis in order to establish which parameters that affect the make-or-buy decision and therefore are relevant to include in the model. The selected parameters also need to be specified, in order to determine how they can be decomposed, measured and prioritized in the decision model. Based on this, the first draft of the decision model will subsequently be developed and presented. In order to create a deeper understanding of the purchasing decision at SED, data and further information will be collected and act as support in the in depth analysis. As a part of the in depth analysis, the make-or-buy model will also be validated by potential end-users at SED. According to the findings, the first draft of the model will thereafter be evaluated and improved into a final version. Below, in figure 15, an illustration of the research process is given.

In order to define which actions that need to be conducted in each stage, specific research question will be further identified in the following sections.
4.2.1 Initial analysis
The first stage of the study is to evaluate which parameters that affect the make-or-buy decision. When executing this, parameters that are central to SED’s operations need to be settled. This is essential in order to be able to create a decision model that is consistent with the corporate strategy, which is of high importance according to McIvor (2000), as well as Brown and Wilson (2005). By thoroughly examining the contemporary academic findings and through considering SED’s corporate strategy, the first draft of parameters will be obtained. In order to achieve this, the following research question needs to be considered:

**RQ1: What parameters are significant to consider in a make-or-buy decision, according to contemporary academic findings as well as SED’s corporate strategy?**

When the preceding research question has been investigated, the resulting parameters will be summarized and further used in the subsequent stages.

Based on the list of parameters that affect the make-or-buy decision, the next step is to investigate how the respective parameters can be decomposed into sub-parameters and how these should be measured. This is supported by McIvor (2000) who state that it is significant to determine how and why the selected steps and parameters should be used in the model. As can be deduced from the theoretical framework, most concepts and parameters are hard to clearly define and specify why a further decomposition into sub-parameters is necessary. Furthermore, most authors divide the parameters into several of constituents, which further support decomposition of the parameters. Moreover, as SED request a method that is user friendly, it is necessary to provide a model that is simple and straightforward. This is in line with McIvor (2000) statement that a decision model should be divided in logical and sequential steps. Next, it needs to be determined how the list of reviewed parameters and sub-parameters should be prioritized. Finally, it is also necessary to settle if any parameter is a prerequisite for the outsourcing decision and therefore should be considered as a knockout criterion. To enable this, the following questions need to be considered:

**RQ2: How should the parameters be decomposed and measured?**

**RQ3: How should the sub-parameters be prioritized?**

**RQ4: Is any sub-parameter a knockout criterion?**

4.2.2 First draft of the make-or-buy decision model
After having specified the selected parameters, the first draft of the make-or-buy decision model can be developed. In order to accomplish this, it is necessary to determine how the parameters should be represented in the model. This is supported by the variety of make-or-by decision models described in the theoretical framework, which illustrate that this type of model could be configured in many ways. Hence, when constructing the decision model, it is vital to take the aim of the model, as well as context, into
4.2.3 In depth analysis

Subsequently, it will be investigated if the first draft of the make-or-buy decision model can be improved in any way through execution of an in-depth analysis. In order to aid this procedure, a calculative case study will be performed as well as interviews with representatives from different functions at SED. In addition to this, some of SED’s suppliers will also be visited in order to contribute with a new perspective. Finally, the opinions of the employees at SED will be taken into consideration through a workshop at SED. According to Fill and Visser (2000), this is of high importance in order to be able to identify the contextual circumstances. As SED request a user friendly and context specific model, it is relevant to evaluate if the model can be improved or simplified in any way. In order to achieve this, the following question thus needs to be examined:

**RQ5: Can the make-or-buy decision model be improved in any way, with regard to the context of SED?**

4.2.4 Final version of the make-or-buy decision model

Based on the input that was received from the case study, the external and internal interviews as well as the workshop, the decision model will be improved accordingly. It will hence be determined how the make-or-buy decision model can be improved, with regard to the identified proposals in the previous section. Hence, it will be determined how any additional parameters should be represented in the model and whether any existing parameters should be modified and how. The model will also be revised to ensure that the respective parameters have been given enough importance and that the make-or-buy decision model is well adapted to the end-user.
5 Method

This chapter initially gives a brief description of how the research process is conducted. Thereafter, the method is discussed in more detail, for each stage in the process, in order to provide a thorough view of the procedure of the investigation. The credibility of the report is discussed successively in each phase as well as actions that have been taken in order to increase the reliability, objectivity and validity of the investigation.

5.1 Type of study

Patel and Davidson (2003) describe that most investigations can be classified depending on how much knowledge that is acquired before the study is conducted. They further explain that a study is of explorative nature if the existing knowledge prior to the investigation is limited. In explorative studies, the primary purpose is to acquire extensive knowledge within a specific research area. If the study, however, concern areas where there already exist a certain amount of knowledge prior to the investigation, the investigation is of a descriptive nature. Descriptive studies aim to further describe some central conditions of occurrences in either the past or present time. Finally, Patel and Davidson (2013) conclude that an investigation also can be hypothesis testing, which is appropriate in research areas where there exists an extensive amount of knowledge. The main purpose of this type of studies is to derive assumptions regarding conditions in reality and test these.

Similar to Patel and Davidson (2013), Björklund and Paulsson (2012) conclude that the amount of existing information prior to the investigation determines which type of study that is appropriate. They further classify the different types of studies in the categories, explorative, descriptive, explanatory and normative studies. The first two categories, explorative and descriptive, correspond to Patel and Davidson (2013) definitions. Furthermore, according to Björklund and Paulsson (2012), an explanatory study aims to both describe and explain, in order to acquire extensive knowledge within a specific research area. If the main aim with the investigation, however, is to propose suggestions, the study is of a normative nature (ibid). Thus, as this investigation aims to both attain more extensive knowledge within a specific research area as well as to present recommendations, the study is of an explanatory and normative nature.

Moreover, a study can also be quantitative or qualitative based on how the collected information is generated, processed and analyzed according to Patel and Davidson (2013). The study is of a quantitative nature if information is primarily gathered from data and statistical process methods whereas a study which mainly focuses on soft data, such as interviews, is qualitative (ibid). Björklund and Paulsson (2012) agree on this and add that the purpose of the study often indicate whether it is a qualitative or quantitative study. Thus, as this investigation is based on both numerical and non-numerical information and data, the study is of quantitative and qualitative nature. According to Björklund and Paulsson (2012) it is therefore appropriate to collect information through both observations and interviews as well as through surveys and the use of mathematical models (ibid).

5.2 Research procedure

In figure 16 below the research procedure for this investigation is presented. When constructing the process, Patel and Davidson’s (2013) research process was used as inspiration, where the steps are to acquire basic knowledge, specify the problem, determine an appropriate method, execute the investigation, conduct analysis and finally summarize the result. In order to better suit this specific investigation, Patel and Davidson’s research process has nonetheless been modified and supplemented with additional steps. As is visible in figure 16 below, the research procedure is divided in the three phases, planning, execution and grand finale. Furthermore, the planning phase consists of the five stages, writing the problem description, establishing the purpose and delimitations, collecting corporate information and writing a company presentation, theoretical studies and, lastly, founding the problem
specification and method. In the first stage, a better insight was gained regarding the background of the assignment. Next, the purpose was clarified and a deeper understanding of the problem was acquired. In the third stage of the planning phase, a better insight into SED and corresponding operations was obtained and the company presentation was written. Thereafter, a review of contemporary academic findings was conducted in the theoretical research stage. The third and the fourth stage was an iterative process as theoretical findings generated additional input to what information that was interesting to collect from SED and the opposite. Finally, in the last stage of the planning phase, the problem was further specified and an appropriate method was established.

Furthermore, in the execution phase an initial analysis, of both the academic findings and the specific context of SED, was conducted. In the first stage parameters that are central to the make-or-buy decision at SED were identified. Thereafter, the selected parameters were further decomposed and appropriate measurement methods were established. Next, the parameters were prioritized and an evaluation of which parameters that could be classified as knockout criteria was conducted. Based on this analysis, a first draft of the make-or-buy decision model was established in the last stage of the execution phase. In the last phase, grand finale, the last stage of the research procedure was conducted by an in depth analysis where the decision model was validated and improved into the final version in an iterative process. The in depth analysis included interviews at SED, a case study, supplier visits and a workshop. Each of these phases and stages are discussed in more detail in the sections below.

**Figure 16: Illustration of the research procedure, including the three phases**

### 5.2.1 Phase 1: Planning
Initially, a brief problem description of this master thesis was presented by the supervisors at SED. In order to acquire a deeper understanding of the specific requirements and circumstances, a further dialogue with the employer was conducted. In association with this, a first draft of the purpose, directives and delimitations was determined in order to establish a rough plan for the investigation. According to Booth et al (2003), it is advantageous to have a rough plan at an initial stage of the examination in order to avoid confusion and unnecessary actions. Thereafter, a company presentation was compiled through collection of information from the corporate web-portal and conversations with employees from various functions at SED. This enabled the capture of the context and the development of a broader understanding of the complexities of the existing problem. As mentioned before, it is appropriate to collect information through both interviews and data in a quantitative and qualitative study, according to Björklund and Paulsson (2012) why this was taken into consideration. Additionally, two days were spent in
the production. By participating at the assembly lines, further knowledge considering SED’s operations and their products was acquired. Furthermore, this active observation increased the validity of the investigation, as an own perception of the operations could be achieved, in line with Björklund and Paulsson (2012).

Subsequently, relevant areas for the theoretical study were identified by first making a general and broad search on outsourcing and make-or-buy decision making. Appropriate search areas were also obtained through SED’s directives and areas of interest. In more detail, this information was obtained through dialogue with the supervisor and a general problem description of the assignment that was provided by SED. The reason why the theoretical study was performed prior to the dialogue with the supervisor was to avoid a biased information search. With regard to this, it was hence a deliberate strategy to conduct the theoretical search before any further input regarding SED was gained.

According to Booth et al (2003) it is advisory to make a broad and general search in the initial stage of the literature study, in order to identify relevant and reliable sources, why this was taken into consideration. The authors also stress that this process is facilitated by focusing on a main topic or key words, in order to limit the search scope (ibid). Based on the identified areas of interest, a more specific and detailed literature search among prior research in the subject was subsequently performed. The initial search was thus used to identify relevant sources and areas of interest. According to Merriam (1994), another advantage with investigating prior research, and using the information as a foundation when conducting academic studies, is that it minimizes the risk of falling into traps or analyzing a problem that has already been studied. Prior research can also act as a support when determining the method and research process of an investigation (ibid).

Moreover, the collected information was primarily gained from books, articles and prior researches that were obtained through Linköping University. In specific, the search for literature was conducted via the database Unisearch at the university library. One advantage with using a database is that it contains many articles that are summarized in abstracts, which facilitates the decision of which articles that are worth reading (Booth et al, 2003). Thereafter, the theoretical framework was successively constructed. According to Björklund and Paulsson (2012), a negative aspect of using literature in order to construct the theoretical framework is that it is a secondary source and therefore not written with this investigation in mind. Thus, in order to gain a broad and objective view, several authors were reviewed within each area and a continuous theoretical triangulation was conducted in order to increase the credibility in accordance with Björklund and Paulsson (2012). Additionally, the obtained information was critically examined and the context of the studied literature was taken into consideration, which is of high importance in order to increases the objectivity of a study in line with Björklund and Paulsson (2012). Furthermore, reviewing literature is an efficient method in order to quickly gain a broad view of contemporary theoretical findings (ibid).

Finally, as a last stage of the planning phase, the problem specification and method were established. Considering the problem specification, this was constructed by firstly dividing the research process into four stages. Thereafter, research questions were formulated to facilitate the procedure by studying both the theoretical framework and operations at SED. Parallel to this, discussions were held with the supervisors at both SED and the university, in order to ensure that the direction of the investigation was in line with the given directives.

5.2.2 Phase 2: execution
In the second phase of this thesis, the initial part of the investigation was executed. The respective steps of the research process are discussed in more detail in the following sections.
5.2.2.1 Selection of parameters

In order to answer the research question in this stage, a compilation of the existing theoretical framework was performed. When reviewing the theoretical framework, the most common parameters that several of the authors stress as important were taken into consideration. More context-specific parameters that only one author describes as relevant were not included unless they were assessed as highly important to consider at SED. Based on this, a first list of parameters that are important to consider in a make-or-buy decision, from a theoretical perspective, was thus obtained. Thereafter, the corporate business strategy was analyzed in order to not overlook any corporate specific aspects of the decision. In more detail, it is the production strategy that is of interest, as this strategy concerns the areas of this investigation. The other strategies, such as marketing or expansion strategies, were not included in the analysis as these concern topics that are not related to the central aspects of the investigation. By analyzing the production strategy, with the help of the supervisors at SED, the primary list of parameters that are relevant to include in the make-or-buy decision model was thus updated. In table 1 below, this stage’s research question with respective data collection method is presented.

<table>
<thead>
<tr>
<th>Research question</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1: What parameters are significant to consider in a make-or-buy decision, according to contemporary academic findings as well as SED’s corporate strategy?</td>
<td>Compilation of parameters from the theoretical framework. Including parameters acquired from the corporate business strategy.</td>
</tr>
</tbody>
</table>

Table 1: Research question 1

5.2.2.2 Establishing decomposition and measurement methods

This stage involves the specification of selected parameters and, in order to fulfill this, additional theories on how to decompose and measure the selected main parameters were thus collected. Based on the acquired information, the parameters were subsequently decomposed into sub-parameters and appropriate measurement method for each sub-parameter was determined. When decomposing the parameters into sub-parameters, the parameters that SED currently measures were taken into consideration. In order to identify which parameters that SED currently measures, dialogues were held with the supervisor and responsible personnel from different functions. As these sub-parameters already are measured and used at SED, utilizing these sub-parameters hence enables the construction of a more corporate-specific and user-friendly model. When the measurement method was settled for each sub-parameter, a dialogue was held with the supervisor at SED to ensure that the main data was available. In the specific instances where the requested data was not obtainable, the measurement method was adapted to better suit the existing information.

5.2.2.3 Priority of parameters

Next it was established how the sub-parameters should be prioritized in order to act as an aid when determining how the parameters should be represented in the first draft of the make-or-buy decision model. The priority was done by comparing how important the parameters are to SED’s operations and the impact the parameters have on the outcome of the make-or-buy decision. When prioritizing the sub-parameters, no personal views were taken into account but the focus was on the corporation’s main interest. Hence, the priority was executed by the authors of this study, without consulting the supervisor or any other employee at SED in order to avoid bias information and in that way obtain a result that is as objective as possible. In more detail, the priority was done by conducting a pairwise comparison that was inspired by the comparison model analytical hierarchy process. The analytical hierarchy process was used as a foundation as it is useful tool for making decision that optimizes the benefit of an organization, according to the Institute for Supply Chain Management (2015). Furthermore, when conducting the modified version of the analytical hierarchy process, the parameters were compared in pairs. In more detail, a parameter was given the value 1 if it was considered to be equally important to the other
parameter, 3 if it was considered to be more important and 5 if it was considered to be much more important. The other parameter was given the inverted score. Once all the parameters had been compared in pairs, the total scores were normalized and based on this final score the parameters received a priority. The reason why this adapted version of the weighted point model was used was to be able to make a structured and time-efficient analysis that in turn could generate input considering the representation of the parameters in the model.

5.2.2.4 Establishing knockout criteria
Finally, sub-parameters which are considered as prerequisites, either at SED or according to existing theories, were chosen as knockout criteria. In order to verify the selection of knockout criteria, a final check with the supervisor at SED was made. In table 2 below, research question 2 – 4 and their respective data collecting methods are presented.

<table>
<thead>
<tr>
<th>Research question</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ2: How should the parameters be decomposed and measured?</td>
<td>Additional literature studies and dialogue with supervisor. Review of measurement method according to attainable information.</td>
</tr>
<tr>
<td>RQ3: How should the sub-parameters be prioritized?</td>
<td>Analysis of decision model theories and acquired information regarding SED. Execution of a modified version of the analytical hierarchy process.</td>
</tr>
<tr>
<td>RQ4: Is any sub-parameter a knockout criterion?</td>
<td>Analysis of decision model theories and acquired information regarding SED.</td>
</tr>
</tbody>
</table>

Table 2: Research question 2 – 4.

5.2.2.5 Constructing the first draft of the make-or-buy decision model
Based on the information that has been collected in previous stages the first draft of the decision model was constructed. In order to aid this process, existing decision model theories were also analyzed in order to gain further inputs. Hence, the prioritized list of parameters was revised in order to establish how the respective parameters should be represented in the model. Furthermore, a test limit was set for each of the parameters that had been classified as suitable for either individual or collective knockout criterions. These test limits were established by the authors of this study, in order to prevent bias information. In order to validate that the chosen limits were fairly reasonable, they were discussed with the supervisor. Based on the priority of the parameters and the knockout criteria it was thus determined in which order the parameters should be evaluated as well as which parameters that needed to be evaluated together.

5.2.3 Phase 3: grand finale
In the third phase, the decision model was reviewed once more into a final version. The procedure was executed according to the description in the section below.

5.2.3.1 Re-evaluation of the decision model
This step included in depth interviews at SED, a calculative case study, supplier visits and a workshop. The three first steps were conducted in parallel which resulted in an updated version of the decision model. This process was performed in an iterative approach where the model was continuously improved. Based on this, a workshop was held at SED and the final version of the make-or-buy decision model was constructed.
In order to gain insight into how SED is affected by the make-or-buy decision, interviews were held with personnel who have gained several of years of experience at SED. These employees represented several functions at SED, including production, strategic purchasing and research and development. All of the employees that have been interviewed and the department they represent are presented in the reference list. As this report aims to develop a make-or-buy decision strategy with regard to what is best for the whole firm, and not a specific function, it was hence important that all these functions were represented in these interviews. Moreover, in order to increase the validity of the investigation, several of employees were asked the same questions with the aim of avoiding biased information. Furthermore, these interviews were recorded in order to reduce the risk of misunderstandings and hence enhance the reliability of the investigation in accordance with Björklund and Paulsson (2012).

According to Merriam (1994), an interview can be structured to varying degrees. A structured interview is appropriate when the interviewed people are many or the response needs to be able to quantify (ibid). An unstructured interview, however, is appropriate when the interviewer lack sufficient knowledge about the concerned topic (ibid). Hence, the interviews that were held at SED were of a semi-structured nature, as quantification of the result was not necessary and the interviewers had some, but not sufficient knowledge, of the investigated topic, in accordance with Merriam (1994). Thus, by using semi-structured interviews, it was possible to adapt the questions in response to the respondent’s answers in line with Merriam (1994). According to Björklund and Paulsson (2012), semi-structured interviews and the possibility to adapt the questions further enable a deeper understanding, which was the aim of these interviews.

Furthermore, during the interviews, one interviewer was responsible for leading the conversation while the other interviewer took notes, which increase the reliability according to Björklund and Paulsson (2012). Additionally, the interviewed personnel had the ability to later review a summary of their response, which enhances the correspondence and validity of the investigation in accordance with Björklund and Paulsson (2012). One advantage with using interviews is that the information obtained is primary and therefore has direct relevance for the study (ibid). Face-to-face interviews also give the opportunity to interpret the respondent’s body language and pitch, which provide further information (ibid). Hence, this was taken into consideration when conducting the interviews. In order to be able to identify people for the interviews, there was initially a dialogue with the supervisor at SED.

In order to answer research question 5, a calculating case study was used as a tool. When conducting this case study additional corporate data was collected in order to evaluate the selected parameters. According to Björklund and Paulsson (2012), the usage of corporate specific documentation and deep interviews is preferable when the aim is to obtain a thorough and profound investigation. Furthermore, the case study was executed by testing the first draft of the model, by using it, in order to investigate whether any essential parameter was missing in the model. In addition to this, the case also aimed to evaluate how user friendly the first draft of the model was and whether any simplification was necessary. The purpose of the case study was hence to solely test the make-or-buy decision model, and the outcome of the investigation was therefore not of importance.

This calculation case study was performed by investigating which is the most suitable make-or-buy approach regarding the modules power pack and valve plate. The reason why these specific modules were chosen for the case study was primary that they are both on a suitable assembly level. Additionally, the current make-or-buy setups differ between the two modules. In more detail, the power pack is produced by an external supplier and the valve plate is currently assembled in-house. This was advantageous when conducting the case study, as further insight was gained regarding how the make-or-buy setup affects the analyzed parameters. Additionally, it was evaluated if there was any difference in using the model depending on the current make-or-buy setup. By completing the case study, and by
executing the interviews, it was hence possible to discover if there was any delimitation in the model or contextual aspects that needed to be modified.

Furthermore, in order to gain further insight into what parameters that are important to include in the make-or-buy decision model, based on the supplier’s perspective, three of SED’s current suppliers were visited. During these visits, semi-structured interviews were held with employees mainly responsible for the relationship with SED. The suppliers that were chosen for these visits were supplier C, D and F. These suppliers were chosen as they all have different setups with SED today, which hence resulted in additional input regarding the advantages and dis-advantages of different setups. In more detail, supplier D is responsible for supplying the power pack to SED, which was used as input in the model when it was tested in the case study. By visiting supplier D further input regarding the case could thus be gained which was highly valuable. All of the suppliers that were visited were chosen based on a dialogue with the supervisor at SED.

Furthermore, in order to validate the make-or-buy decision model a workshop was held with employees with different positions at SED that are potential end users of the model. This method is supported by Meriam (1994) who state that it is highly important to verify the result by using different methods and sources of information. Meriam (1994) also conclude that the reliability of a study can be increased by allowing colleges and people that have been interviewed to reviewed the collected information. With regard to this, representatives from different functions were selected and invited to participate in the workshop. These people were furthermore identified through a dialogue with the supervisor at SED. The purpose with the workshop was to validate the model and ensure that it was adapted to SED’s specific needs and context. The first draft of the decision model was thus updated, according to the input that was received during the internal and external interviews and the case study, before the workshop was held. The reason for this was to ensure that the focus of the workshop was constructive and not focusing on areas of improvement that had already been identified. As a consequence of this, the workshop was held at a very late stage in the process of this investigation.

Moreover, at the workshop, a presentation of the investigation and the obtained result was conducted in order to give all participants a common view of the subject of discussion. In more detail, the discussion was initiated by asking the employees if any parameters were overlooked or given too low priority in the model as well as opinions regarding the general structure and set limits. In the discussion, the question regarding the user friendliness of the model and if any addition regarding usage was desirable was also raised. In table 3 below, the research question and the applied method for answering this are presented.

<table>
<thead>
<tr>
<th>Research question</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ5: Can the make-or-buy decision model be improved in any way, with regard to the context of SED?</td>
<td>Semi-structured interviews with personnel representing different departments at SED. Testing the first draft of decision model by a calculating case study. Semi-structured interviews with suppliers. Workshop at SED.</td>
</tr>
</tbody>
</table>

**Table 3:** Research question 5

5.2.3.2 Constructing the final version of the make-or-buy decision model

Based on the feedback that was received during the workshop, the model was modified into a final version. When modifying the decision model, concern was not taken to personal interests but the focus was on identifying the corporate needs and priorities.
6 Initial analysis

In this chapter, parameters that affect the make-or-buy decision will be identified. This will be done with regard to both contemporary academic findings as well as context specific conditions at SED. Thereafter, the parameters that were selected will be specified and decomposed, in order to clarify how the measurements should be conducted. Subsequently, the parameters will be prioritized and whether they should be regarded as knockout criteria or not will be determined. To facilitate this process, the research questions formulated in the problem specification act as a guide.

6.1 Introduction to research questions

The first stage of the initial analysis is to determine which parameters that affect the make-or-buy decision. Next, the selected parameters will be decomposed into sub-parameters and appropriate measurement methods will be determined. In order to facilitate the use of the decision model, an analysis will be conducted in order to evaluate whether any sub-parameters describe similar measurements and thus can be combined. Next, the sub-parameters will be prioritized and an assessment will be conducted in order to determine if any sub-parameters should be regarded as a knockout criterion. To aid this process, the following four research questions have been identified:

RQ1: What parameters are significant to consider in a make-or-buy decision, according to contemporary academic findings as well as SED’s corporate strategy?

RQ2: How should the parameters be decomposed and measured?

RQ3: How should the sub-parameters be prioritized?

RQ4: Is any sub-parameter a knockout criterion?

6.2 Selection of parameters

Beginning with reviewing the theoretical framework, and identifying parameters that are stressed as important to consider in the make-or-buy decision, the following parameters are obtained:

- Consistency with the overall cooperate strategy
- Core competence
- Access of knowledge and resources
- Flexibility
- Efficiency
- Time aspect
- Quality
- Risks
- Costs

The importance of developing a make-or-buy strategy that is consistent with the overall cooperate strategy is emphasised by McIvor (2000) who stress the need to view the decision strategically. This view is further supported by the authors Brown and Wilson (2005), as well as Kulkarni and Jenamani (2008). Furthermore, the need to consider core competence in the make-or-buy decision is highlighted by several authors. Among others, Quinn and Hilmer (1995) clarify the significance of evaluating which internal activities that produce value when establishing an appropriate make-or-buy strategy. By doing this, the firm avoids the risk of spreading critical knowledge, which the organization’s competitive advantages relay on, to external parties (ibid.). Kumar et al (2010) agree on this and opine that evaluating which activities that are core competence and not should be the first step of the decision process.

When reviewing the theoretical framework, access of knowledge and resources as well as flexibility were
identified as important parameters to consider in the make-or-buy decision. In specific, access of knowledge and resources is a relevant aspect to consider, as it is not economically advantageous for a company to be self-sufficient, as stated by Power et al (2006). This is further supported by Malmgren (2010), as well as Assid et al (2015), who add that access of knowledge and resources can increase the firm’s capacity. Similarly, flexibility is highlighted as an important parameter to take into consideration in the make-or-buy decision, according to Arias-Aranda et al (2011) and Scherrer-Rathje et al (2014) among others, as this parameter is strongly connected to a firm’s ability to achieve competitive advantages. Scherrer-Rathje et al (2014) state that a firm’s capability to act flexible can be both positively and negatively affected by an outsourcing setup, why it is essential to take this parameter into consideration before the make-or-buy decision is made. Furthermore, the need to consider efficiency, when making the decision, is stressed by Bakhtiari (2015) who argue that there is an immediate productivity improvement for firms that decide to transfer activities to an external supplier.

Other factors that were identified as essential in the make-or-buy decision are the time aspect, the quality of the produced products, eventually risks and the total cost. Beginning with the aspect of time, Kulkarni and Jenamani (2008) state that it is necessary to evaluate the effect on lead time when evaluating the make-or-buy decision. This is further supported by Oskarsson et al (2013), who stress the importance of considering lead time in any corporate decision, as it often is highly significant to the customer. Quality is also highlighted as a crucial parameter to assess, as it is often challenging to ensure a satisfactory level when transferring activities or processes to an external supplier, according to Setterwall (2013). Moreover, as emphasized by several authors, it is also vital to consider risks, before the decision is made. Among others, Abrahamsson et al (2003) and Lee et al (2012) mention different risks that are associated with the make-or-buy decision, including some that are hard to detect prior to the occurrence. Finally, the necessity to consider costs are highly stressed by authors such as Vining and Globerman (1999), who further explain that both production costs and transaction costs are relevant to take into consideration when a firm faces make-or-buy decision. In order to avoid sub-optimization, a proper total cost analysis approach is advantageous when a shift in the logistic setup is planned, according to Oskarsson et al (2013).

Next, it is relevant to investigate which parameters that can be identified as important to take into consideration in a make-or-buy decision by reviewing SED’s corporate business strategy. In specific, as this study is a request by the production function at SED, it is the strategies that relate to the perspective of the production department that is of interest. Through analysis of the production strategy, the following parameters are obtained:

- Flexibility
- Costs
- Core competence
- Efficiency
- Quality
- Lead time
- Stock level reductions

As stated in the production strategy, the firm’s production operations should be flexible in order to meet the varying customer demand. With regard to this, flexibility is a parameter that is essential to consider when conducting the make-or-buy decision. Similarly, SED’s production strategy specifically state that focus should be on reducing the total production cost throughout all activities and processes at the firm, which makes it necessary to assess costs. Moreover, as made explicit in the corporate mission, there is also an aim to concentrate the business on core activities in order to achieve an efficient production. Hence, both core competence and efficiency are important to consider in the make-or-buy decision.
In the corporate mission and the production strategy, it is also evident that there is an ambition to continuously improve quality and ensure that all parts of the processes are conducted correctly. With regard to this, it is relevant to include aspects of quality in the decision model in order to ensure high quality of the products regardless if some parts of the business is entrusted an external party or not. Other aspects that are highlighted in the production strategy are that efforts should continuously be made to reduce the lead time, both up and down stream in the supply chain, as well as stock level reductions. Hence, these parameters will also need to be considered in the decision model, according to the production strategy.

By analyzing the theoretical framework as well as SED’s business strategy, two lists of parameters were obtained. By further analyzing and combining these lists of parameters, a unified and final list of parameters that are important to consider when facing the make-or-buy decision at SED was obtained. The first parameter that was obtained when analyzing the theoretical framework was consistency with the overall cooperate strategy. As the development of the make-or-buy decision model, and the selection of parameters, will be executed with regard to SED’s corporate strategy, this parameter is already taken into consideration. Therefore, it is not necessary to include this aspect in the final list of parameters. Furthermore, the parameters core competence, costs, flexibility, efficiency and quality are highlighted as important parameters to consider by both academic findings and SED. These parameters will thus be included in the model.

Moreover, when analyzing the contemporary academic findings, the parameters access of knowledge and resources, time aspect and risks were also obtained. All of these parameters will therefore be included in the list of final parameters, as they are highly significant to consider in the decision model. Finally, in SED’s corporate strategy, the parameters lead-time and stock level reductions were also emphasized as important. Lead time, however, is included in the more general parameters time aspect. Furthermore, stock level reductions will be included in the parameter cost, where the cost of keeping articles in store and the cost of the risk that the stock level generate, will be quantified. Hence, the final list of parameters that are important to consider when making the make-or-buy decision at SED is as follows:

- Core competence
- Costs
- Flexibility
- Efficiency
- Quality
- Time aspect
- Risks
- Access of knowledge and resources

These parameters will be further investigated in the subsequent stages of the execution phase.

### 6.3 Decomposition and measurement methods

The second research question in this stage, RQ2, regards how the selected parameters should be decomposed and measured. The process for answering this question is to review the theoretical framework and by analyzing parameters that are currently used and measured at SED. Thus, depending on what data that is available at SED, decomposition and appropriate measurement methods will be adapted accordingly. Furthermore, as several of the identified parameters are closely connected to each other it is necessary to establish if any parameters or sub-parameters describe similar measurements and thus can be combined. When conducting an analysis of the considered parameters’ interrelations and priority, it is important that the parameters are given the correct weight and hence it would be misleading to describe the same sub-parameter in several of main-parameters. With regard to this, in the instances where the definitions of the sub-parameters overlap, the implication of each parameter is further
analyzed and subsequently it is determined within which parameter the considered aspect should be discussed. Thus, the aim is to avoid discussing the same aspect in several sections.

Furthermore, as the make-or-buy decision model will be used to evaluate the transfer of a module either from the internal production to an external supplier or the opposite, this need to be taken into consideration when establishing the measurement methods. In more detail, the decision model will be used by comparing the current make-or-buy setup with an estimation of the considered option in order to determine which is the most preferable. Another aspect that needs to be taken into consideration when establishing how to measure the different parameters is that the considered option can regard a whole module on a higher level, part of a module, or a complete rig. In the following sections, decomposition and measurement methods for the respective parameters are established. Nevertheless, how the result of the presented measurement methods should be interpreted and used in the model will not be established in this section but in the section considering the first draft of the decision model.

Moreover, in some instances it is necessary to send an enquiry to potential suppliers in order to receive a quotation as an estimated guess is insufficient. This view was supported by the supervisor at SED who agreed that without sending out requests of quotations, the make-or-buy decision analysis would be much less valuable. How an investigation considering how to determine whether a specific supplier is appropriate or not should be conducted, however, this will not be established in this report according to previous delimitations. In addition, SED already has a valid process for supplier evaluation and selection and hence this is not requested, according to the supervisors at SED.

6.3.1 How to decompose and measure core competence

As there is an ambition at SED to focus on core competence, as stated in the production strategy, this is an important parameter to consider in the make-or-buy decision model. According to Quinn and Hilmer (1995), there are several criteria that need to be fulfilled in order for an activity or a corporate competence to be classified as core competence. These criteria were summarized, in the theoretical framework, and can be used as a foundation when an investigation, of whether a specific activity or competence can be considered as a core competence, is conducted. Below, these core competence criteria, according to Quinn and Hilmer (1995), are listed and formulated as questions to facilitate the identification of company core. Some of the questions are more complex and these are therefore decomposed into sub questions in order to ease the assessor’s procedure.

Firstly, Quinn and Hilmer (1995) highlight that a core competence is a cross functional knowledge set or skill. In order to investigate if this is valid for a specific activity or competence at SED, the following question with associating sub questions should be considered:

- Can the competence or activity, which is under consideration, be classified as a cross functional knowledge set or skill?
  - Do representatives from several departments and functions cooperate in order to execute the activity?
  - Is the activity or competence hard to imitate?
  - Is the activity or competence hard to replace by a substitute?

Secondly, according to Quinn and Hilmer (1995), a core competence can be defined as a flexible platform that is capable of adaption and evolution in the long term perspective. Therefore, with the intention of identifying core competences at SED, the questions stated below need to be investigated:

- Is the competence or activity a flexible platform, that in the long term perspective is capable of adoption or evolution?
  - Is the market demand of the considered activity regularly reassessed in order to always be able to offer what the customers value over time?
  - Is the considered activity or competences directly adapted according to this market
demand?

- Are there a foundation and prerequisites that enable SED to make these adaptions easily?

Furthermore, core competences are limited in numbers, according to Quinn and Hilmer (1995). More specifically, two or three is sufficient in order to be able to perform these activities superiorly and enable managers to focus their attention. Consequently, it is highly relevant to investigate how many competences or activities that are considered to be core at SED, why the following question need to be answered:

- How many competences or activities are considered to be core competences at SED?

In order to attract customers, a firm needs to fill a market knowledge gap where investments in intellectual resources can be highly leveraged, according to Quinn and Hilmer (1995). Moreover, this implies that the specific activity or competence enables SED to outperform its competitors in some way, which is a requirement in order to be classified as core competence. Subsequently, the following question, with associated sub questions preferably should be considered:

- Is the considered activity a unique source of leverage in the value chain?
  - Is SED the only supplier of the considered activity?

According to Quinn and Hilmer (1995), at least one of a company’s core competences directly should relate to the firm’s customer in some way. As stated above, a long term perspective also needs to be taken in order to serve the customer in the best manner and to justify the core competence label (ibid.). Furthermore, the below formulated question should be evaluated:

- Can the competence or activity be considered as an important aspect for the customer in the long run?

Moreover, for a competence or activity to deserve to be classified as a core competence, it needs to be an area where the company can dominate and perform more effectively than the competitors as a consequence of strong focus. Hence, the question below needs to be investigated in order to assess if the considered competence or activity is company core at SED:

- Is the competence or activity an area where the company can dominate and which make the firm able to stay ahead of its competitors?

Finally, a core competence cannot be dependent on a single talented employee. Instead, Quinn and Hilmer (1995) state that a core competence has been transformed from being an employee based competence or skill into a corporate culture or value.

- Is the competence or activity embedded in the organization’s system?
  - Is the considered competence or activity expected to outlive the current staff members?

Additionally, as stressed by Abrahamsson et al (2003), corporate activities can be both strategically important and crucial for the firm’s business, but still not be classified as a core competence. As a consequence of this, it is relevant to investigate existing linkages between SED’s activities. By doing this, an understanding, of what impact different outcomes of the make-or-buy decision will have on the remaining business of the firm, can be developed, according to Abrahamsson et al (2003). Consequently, the risk of defining SED’s core competences too narrowly, and outsource an activity that will cause complications for the main business, can be avoided. As a support in this investigation, Arnold’s (2000) definition of company core and close-core activities can be used. Subsequently, the following questions should be evaluated if the considered competence or activity, according to the answers of above stated questions, not can be classified as a core competence:

- Can the considered activity be categorized as a close core activity?
Initial analysis

- Are there tight couplings between the considered activity and any defined core competence?
- Is any defined core competence dependent on the activity, which is under investigation?
- Is any defined core competence expected to be negatively affected by outsourcing of the investigated activity?

Walsh and Linton (2001) suggest that in order to identify core competences, not only the internal operations should be taken into consideration, but the external environment as well. Thus, they propose that the competitors’ competences and capabilities should be investigated as well as the industry’s market and customer demand. Through this, a holistic view of what activities that really create competitive advantages and customer value can be created. Furthermore, involvement of managers is stated as a suitable approach in order to identify a firm’s core competences, according to Walsh and Linton (2001), why managerial opinions should be taken into consideration when the core competence investigation is performed at the firm. Finally, if the investigator for some reason was unable to answer the previous questions and if the identification of the SED’s core competences was obscure, below stated question could act as a guideline. In more detail, by a supportive investigation of what is seen as the industry’s most important competences and capabilities by different stakeholders, such as customers, competitors and industry experts, a more accurate view of SED’s core competence can be obtained.

- What is seen as the most industry important competences and capabilities by the firm’s stakeholders?

Furthermore, Abrahamsson et al (2013) state that if too many activities are transferred to an external supplier, the firm faces the risk of having too few value enhancing activities left in-house. The authors thus conclude that, even if the considered activity is not categorized as core competence, it may still not be suitable for outsourcing. Hence, it is necessary to evaluate if SED has control of enough value enhancing activities, which enable the firm to cover all its costs, even if the considered activity is transferred to an external supplier. With regard to this, the following questions are also relevant to consider in the make-or-buy decision:

- If the considered activity is removed from the internal production, will enough value still be generated in-house, in order to gain profit?
  - Does the activity, which is under investigation, correspond to a considerable ratio of the total value of the end product?

When considering the transfer of a module to the internal production, the above evaluation of core competence is not applicable. It is, nonetheless, relevant to evaluate which effect the transfer of the module would have on the SED’s core competence. As stated by van Weele (2010), a firm should focus on its core competence, as there are other firms that can perform the other activities in a more efficient manner. Thus, if SED focuses on too many activities, there is a risk that there will be a limited focus on the core competence, which will decrease SED’s competitive advantage. In order to avoid this, the following questions are thus necessary to consider.

- In the case of transferring an activity from an external supplier to the internal production, is it possible to still have full focus on the existing in-house core activities?
  - Will the managers still be able to devote their attention and time on the core competences?

6.3.2 How to decompose and measure access of knowledge and resources
In order to establish a suitable measurement method regarding access of knowledge and resources it is relevant to investigate how this parameter affects the make-or-buy decision. According to Powel (2006), it is not economically beneficial for a firm to be self-sufficient. In specific, there are suppliers which are better specialized at specific areas of the value chain, and therefore are able to supply resources at a
lower cost (ibid.). Consequently, this parameter has a strong linkage to the cost parameter as access of further knowledge and resources can enable a lower production cost. In more detail, by utilizing better equipment or accessing more competent employees who are able to perform the relevant operations in a more efficient way, it is possible to improve the production cost. Thus, by investigating the production cost of the considered module, both in-house and externally, the possible cost benefits of accessing a supplier’s knowledge or resources will be quantified. Similarly, the same reasoning applies to a module that is currently produced by an external supplier where in-house production is considered as an option.

Another aspect that is affected by the parameter access of knowledge and resources is risk. According to Ritchner and Rognes (2013), it is highly significant to distinguish that, in the case of transferring an activity to an external supplier, there is a risk of losing in-house knowledge. This specifically concerns tacit knowledge, which is not documented at the firm, but rather is linked to individual employees. Scherrer-Rathje et al (2014) agree on this and emphasize the importance of paying careful attention to avoid loss of knowledge. Furthermore, at SED there is a risk of losing competence, despite the existence of documentations of how to assemble the rigs. The reason for this is that regular practice of assembling a specific module is necessary in order to maintain the specific skills. Otherwise, assembly is still possible with support of the documentation, however, it will require a longer assembly time. Hence, it is necessary to evaluate the risks associated with loss of knowledge when transferring an activity to an external supplier. This aspect of knowledge and resources, however, will be further discussed in association with the risk parameter and is thus not further analyzed here.

Similar to the parameters cost, time is also relevant to consider when discussing the parameter access of knowledge and resources. As previously discussed, access of deeper knowledge and resources can enable a firm to supply products or services to a lower cost and better quality. Likewise, utilizing valuable resources and knowledge may also result in shorter lead times, by performing operations more time-efficiently or reducing the number of operations. At SED, lead time is a critical condition in order to satisfy the customers and hence it is necessary to further evaluate the effect of access of knowledge and resources on the obtained lead time. However, this will not be further evaluated here, but a discussion regarding time will be conducted in the section regarding the parameter time aspect.

Moreover, Assid et al (2015) emphasize that it is possible to attain a higher capacity by accessing a supplier’s knowledge and resources. At SED, the question regarding capacity is highly relevant. In more detail, there is an ambition to be able to quickly respond to changes in customer demand, and thus adapt the capacity according to market fluctuations. Furthermore, it is possible for SED to increase their capacity by investing in more human and material resources. However, this solution would result in high fixed costs and as the market demand is volatile, the resources thus would not be used efficiently in times when market demand is low. Therefore, if possible, it is highly attractive to find a more flexible set up. Scherrer-Rathje et al (2014), mention volume flexibility, as one type of flexibility, which regards changes in production volume. Hence, capacity is tightly connected to flexibility and will therefore be treated in greater detail within the flexibility parameter analysis.

Furthermore, Powel (2006) additionally states that accessing suppliers’ knowledge and resources not only can contribute to lower production costs, but a higher quality as well. The reason for this is that a higher knowledge in the specific technology of the industry, or manufacturing operations, may result in a higher quality of the product. Similarly, it is possible to achieve a higher product standard by using resources that enable improvement of the manufacturing operations. In the case of insourcing, the same reasoning applies, as it is of interest to evaluate if greater competence and resources are available in-house or externally. This aspect is thus closely connected to the ability to improve the research and development operation. Through collaboration with the supplier regarding the product development processes, it is possible that more innovative solutions and improvements can be attained than if SED handles the R&D operations themselves. This, however, depend on the agreement with the supplier and whether the
supplier is paid to participate or be responsible for the R&D operations and improvement processes of the products or not. As this aspect concerns the ability to improve the research and development of the products, through accessing a supplier’s access of knowledge, it is discussed here rather than under the parameter quality.

Moreover, access of knowledge and resources is a broad concept and hence it is necessary to investigate whether there are any important aspects of the parameter that are not included in the parameters cost, risk, quality, time aspect and flexibility. Thus, through dialogue with the supervisor at SED, one other main aspects of access of knowledge and resources were identified. This aspect is whether SED, through cooperating with a supplier, can acquire knowledge that can be used in other areas at the firm, which not directly are linked to the outsourced activity. Similarly, when considering insourcing, there is a risk that knowledge, which is not directly linked to the outsourced activity, might be lost when transferring this activity from an external supplier to the in-house production. This aspect will thus be analyzed within the risk parameter while the possibility to gain further knowledge by cooperating with the supplier will be treated in this section. By summarizing the parameters, regarding access of knowledge and resources, that will be treated in this section the following result is thus obtained:

- Improved R&D operations
- Acquiring competitive knowledge

Beginning with the possibility to improve the research and development operations and the improvement processes of the products, this aspect can be hard to evaluate prior to the make-or-buy decision. First, an indication of the possibilities to improve the R&D operations can be given by analyze if any previous collaborations has generated any advantages. Furthermore, it is relevant to investigate the general interest of being included in the R&D operations at the considered supplier. Consequently, it is valuable to keep the following questions in mind when making the decision, in order to make a well-informed estimation of whether it is possible to achieve any benefits within the R&D operations:

- Can the R&D operations be improved, with regard to time or quality, by cooperating with the supplier?
  - Has any previous collaboration generated improved R&D operations, historically?
  - Is the considered supplier interested in a R&D collaboration with SED?

Similarly to the R&D approach, the aspect of whether buying assemble of a module, or part of a module, from an external supplier can enable the transfer of deeper knowledge that is useful in a broader perspective, can be hard to evaluate prior to the make-or-buy decision. Nevertheless, it is useful to evaluate what impact access of suppliers’ knowledge and resources may have on the firm as a whole, not only regarding the investigated module and the most closely connected activities. Thus, the following questions can act as a guideline:

- Is it possible to achieve competitive knowledge, apart from knowledge concerning production of the considered module, through transferring an activity to an external supplier?
  - Has any previous collaborations generated access of knowledge that is useful in a broader perspective at the firm, historically?
  - Does the supplier possess higher or broader knowledge in any area or aspect?
  - Does the supplier’s culture encourage inter-firm collaborations and knowledge transfer?

6.3.3 How to decompose and measure flexibility

According to Scherrr- Rathje et al (2014), flexibility can be defined as “the ability to change or react with little penalty in time, effort, cost or performance”. Hence, flexibility is clearly connected to the parameters time and cost, as it is not only a measurement of whether change is possible but to what price as well. Furthermore, Arias-Aranda et al (2011) state that flexibility can reduce a firm’s vulnerability to alterations in both short and long term issues. Thus, flexibility is also connected to the parameter risk. Therefore, as
flexibility is a broad concept that is linked to several other parameters, it is necessary to define and decompose it into measurable sub-parameters.

In order to decompose the parameter flexibility, it can be divided into the four flexibility categories; product, volume, mix and labor competence in accordance with Scherrer- Rathje et al (2014). As product flexibility describe the ability to easily make changes in the offered product portfolio, while volume flexibility refers to the ability to change the production volume, these concepts capture different aspects of flexibility and are thus, in accordance with the contemporary academic findings, important to include in the model. At SED, high volume flexibility is particularly desirable as there is a need to handle variations in customer demand. Furthermore, mix flexibility regards the ability to change the production ratio between the offered products. As argued by Stahre (2015), however, this is a combination of volume and product flexibility. Mix flexibility will thus not be included in the model, as this aspect of flexibility will be evaluated indirectly through the other flexibility sub-parameters. Continuing with labor competence flexibility, it defines an additional concept of flexibility, namely how well the workforce can deal with modifications in the product assortment. This aspect is closely connected to the risk of losing competence, as high competence level among the firm’s employees will result in high labor competence flexibility and vice versa. Therefore, this aspect of flexibility will be further discussed in the risk section.

Furthermore, all of Scherrer-Rathje et al’s (2014) parameters regard the ability to adapt in the short-term perspective. Nevertheless, when investigating the make-or-buy decision at SED, it is also relevant to evaluate the long-term perspective. In particular, as the ability to adapt the produced output according to variations in demand is highly attractive at SED, it is of interest to assess what level of output that can be attained in the long run. In order to clarify, this aspect is closely connected to the long-term growth prospects. Therefore, the parameter long-term capacity will be included in the make-or-buy decision model.

Furthermore, Tan and Sia (2006) divide flexibility into the four dimensions modifiability, robustness, ease of exit and new capability. The first two dimensions, modifiability and robustness, regard the ability to make alterations in the production assortment as well as the ability to cope with variations in the demand. Hence, these two dimensions are included in the types of flexibility that Scherrer-Rathje et al (2014) discuss. The third dimension ease of exit, however, is a measure of how fix the outsourcing relationship is and how dependent the firm is on the supplier. Abrahamsson et al (2003) similarly discuss the concept strategic flexibility, which can be achieved by avoiding investments in new technologies or physical structures. The aspect of strategic flexibility is, thus, closely connected to Tan and Sia’s (2006) parameter ease of exit, as it refers to how fix the outsourcing relationship is. Moreover, both these parameters are closely connected to the risk of being too dependent on the supplier and will, therefore, be further evaluated in the section about risk. Furthermore, Tan and Sia’s last dimension of flexibility, new capability, address radical changes in the external environment and will not be included in this investigation as it is not a determinant factor for the make-or-buy decision but rather regards extreme circumstances. Finally, another aspect of flexibility that also needs to be considered is time flexibility, defined by Stahre (2015). This aspect of flexibility relates flexibility to the aspect of time, and whether it is possible to make temporary and immediate alterations in response to changes in the customer demand. Time flexibility is thus differentiated from lead time, as this time parameter is fixed.

By summarizing the different aspects of flexibility that will be included in the model, the following sub-parameters are obtained:

- Product flexibility
- Volume flexibility
- Time flexibility
• Long-term capacity

Thus, in order to successfully evaluate these aspects of flexibility in the make-or-buy decision model, it needs to be determined how they can be measured. Beginning with product flexibility, Scherrer-Rathje et al (2014) opine that high asset specificity can have a negative impact on flexibility as the supplier may need to invest in new technology. With this in mind, the following questions have been formulated to aid the process of evaluating product flexibility in the make-or-buy decision context:

• Is it possible to achieve higher product flexibility through a change make-or-buy setup?
  ➢ How asset specific is the considered module?
  ➢ Which party owns the specific asset?

Continuing with the next sub-parameter, Scherrer-Rathje et al (2014) argue that a company’s volume flexibility can be increased by gaining access to a supplier’s eventual economies of scale and scope. However, the authors state that this depends on whether the firm needs to compete with other customers for the supplier’s capacity. It is thus relevant to investigate whether SED is an important customer, that stands for a considerable ratio of the supplier’s production. Furthermore, Tan and Sia (2006) argue that it is hard to utilize a supplier’s generic capability, and economies of scale, if the transferred activity is highly specialized. In addition to this, the degree of volume flexibility that the supplier can achieve depends on how many of the employees that are capable of producing the considered module and whether these can perform other tasks at the firm as well. The reason for this is that it is more likely that the supplier can handle variations in demand, if the employees are able to move between different operations.

Thus, in the case of outsourcing, the following questions are relevant to consider:

• What interval of incoming customer orders is SED able to handle every month?
  ➢ How many employees are capable of producing the module at SED and hence are able to execute several production operations? How many of these are capable of performing other tasks in the internal production?
  ➢ What possibilities of hiring external and temporary workforce exist?
• What expected interval of incoming orders is the supplier able to handle every month?
  ➢ Do the considered suppliers focus their business on production of the considered module, and thus are characterized by economies of scale and scope?
  ➢ Is SED an important customer for the supplier, standing for a considerable ratio of the supplier’s total turnover?
  ➢ How standardized is the considered module?
  ➢ How many employees are expected to be capable of producing SED’s module at the supplier and hence are able to execute several production operations? How many of these are capable of performing other tasks at the supplier’s production?

Similarly, in the case of considering the transfer of an activity to the internal production, the following questions should be evaluated:

• What interval of incoming orders is the supplier able to handle every month?
  ➢ How many employees are capable of producing SED’s module at the supplier and hence are able to execute several production operations? How many of these are capable of performing other tasks at the supplier’s production?
• What expected interval of incoming customer orders is SED able to handle every month?
  ➢ How many employees are expected to be capable of producing the module at SED and hence are able to execute several production operations? How many of these are capable of performing other tasks in the internal production?
What possibilities of hiring external and temporary workforce exist?

In order to acquire a better understanding of what demand on volume flexibility that is required, it can also be useful to investigate the following questions:

- What demand on volume flexibility is required?
  - How has the customer demand changed and varied, historically?
  - According to forecasts, what is the expected demand in the next 12 months?

Moreover, in order to evaluate the sub-parameter time-flexibility it is relevant to evaluate if either SED or the potential supplier has implemented good routines for handling rush orders and last-minute changes in the product. Other aspects that might give an indication of how high time-flexibility can be attained is the power-balance relation with the supplier, how important SED is as a customer and whether the supplier is service minded. The reason for this is that if the supplier is eager to satisfy SED’s demands, there is an increased likelihood that a relation with the supplier will result in an increased time-flexibility. Furthermore, it is also relevant to investigate the internal possibilities regarding time flexibility at SED. Thus, the following questions have been formulated to aid the assessment:

- Is it possible to achieve a higher degree of time-flexibility through collaborating with an external supplier?
  - Are there any routines for rush-orders at SED and the potential supplier?
  - Are there routines for quickly handling time-critical changes at SED and the potential supplier?
  - How service-minded is the considered supplier?
  - How is the power balance relation between SED and the potential supplier?
  - Is SED an important customer for the supplier, standing for a considerable ratio of the supplier’s total turnover?
  - What internal possibilities regarding time flexibility exists at SED?

In order to evaluate if it is possible to attain a higher level of capacity in the long-term perspective, it is relevant to investigate whether the considered supplier possess any unutilized resources. If the supplier for example owns facilities that are currently not used for the internal production, it might be possible to utilize these if there is a steady increase in demand. Furthermore, by analyzing if the supplier has increased their production historically, inputs can be gained regarding how likely it is for the supplier to be able to increase their production if needed. Finally, it is also relevant to investigate if there are any other reasons to believe that the supplier is more or less capable of achieving a higher degree of long-term capacity.

- Is it possible to achieve a higher degree of long-term capacity by collaborating with an external supplier?
  - Does the considered supplier possess investments or unused assets that enable them to increase their capacity in the long run?
  - Has the considered supplier increased their production, historically?
  - Is there any other reasons to believe that the considered supplier have the ability to increase their long-term capacity?

6.3.4 How to decompose and measure efficiency

Olhager (2000) state that efficiency refers to making things in the right way, in order to achieve a low production costs per unit. Hence, it is clear that efficiency is closely connected to costs. This conclusion is also supported by OECD’s (2015) definition of efficiency, which state that efficiency is the comparison of
what is actually produced and performed with what can be achieved with the same consumption of resources. From this definition it is also apparent that in order to measure efficiency, the achieved output needs to be measured. Heshmati (2003) elaborate on both input and output factors of efficiency and conclude that capital, labor, material and energy often constitutes as inputs while produced products, either in physical quantity or in monetary values, account for the output.

Regarding SED, the input factors of efficiency can all be measured as some sort of cost, either connected to material, labor or some other type of resources. Concerning the output, however, it does not suffice to simply measure the produced units. Rather, the aspect of both time and quality also needs to be included in order to fully capture the meaning of efficiency. The reason for this is that in SED’s case, it is not only the number of produced modules or rigs per unit cost that are of importance, but also the attained quality and the achieved lead time. This is also in line with Olhager (2000) who states that efficiency refers to making things in the right way, that is, not only making things to low costs. Furthermore, at SED, the efficiency of the supplier is in fact not of interest but rather it is the outcome of the efficiency that is of importance. In order to clarify, SED are interested in buying from suppliers who can provide high quality modules, to a short lead time and to low costs. Thus, a high efficiency is indirectly of interest but it is sufficient to measure the outcome, namely cost, lead time and quality. With regard to this, efficiency will not be included as an independent parameter in the model. Nonetheless, it will still be represented indirectly, trough the respective parameters cost, quality and lead time.

6.3.5 How to decompose and measure time aspect

Oskarsson et al (2013) stress that lead time can be defined and measured in many different ways, depending on what process that is considered. At SED, the lead time that is relevant to consider is the time from that a customer makes an order until the order is delivered. This process in turn consists of several sub lead times. First of all, the order needs to be received and confirmed by the market function and thereafter communicated to the production function. Once the production has received the order they need to plan the manufacture of the order. Given that there are open positions in the production plan, the shortest due date for initializing the manufacturing of the order is the lead time it takes to order all the desired call-off articles. Articles that are ordered to stock, however, do not affect the lead time towards the customer, as they are already stored in-house. Moreover, the total assembly lead time and the transportation to the end customer also constitute sub lead times that affect the total lead time towards the end customer.

When making a make-or-buy decision, nonetheless, not all sub lead times are of interest, as some are kept constant regardless of whether a module is assembled in-house or not. The sub lead times that are unaffected are the time it takes for market to receive, confirm and communicate the order of a drill rig forward, planning the manufacturing of the order as well as transportation to the end customer. Thus, the sub lead times that remain are the time it takes from ordering to the arrival of call off articles, including whole modules, as well as the total assembly time. In more detail, when evaluating the alternative to produce a certain module in-house, it is the lead time from ordering to receiving the call-off articles that this module consists of, if any, that need to be estimated. Additionally, the assembly time of that specific module also needs to be assessed in this case. The time of interest is the assembly lead time and not the total amount of hours it take to assemble the considered module, as parallel assemble might occur. Furthermore, when evaluating the alternative to transfer a certain module to an external supplier, it is the lead time from ordering to receiving the module that needs to be estimated.

Furthermore, another time aspect that might be affected by the make-or-buy decision is the time it takes to identify the cause of any eventual errors in the modules or products. However, in the instances where the errors can be tied to the supplier’s production, the supplier is responsible for the cost. Thus, the supplier pays for the time it takes to fix the errors. This aspect is therefore closely connected to the parameter cost and will be further elaborated in the cost section. Moreover, by collaborating with the
supplier it might be possible to reduce the firm’s design cycle times, as stated by Quinn and Himler (1995). This aspect, however, has already been included in the section regarding access of knowledge and the possibility to improve the research and development operations.

The relevant time aspects that have been identified are subsequently the sub lead times; lead time of call of articles and assembly time in the case of internal production and lead time of the module in instances where an external supplier provides the module. These sub lead times are commonly referred to as simply lead time:

- **Lead time**

When evaluating the make-or-buy decision, the lead time of the eventual call of articles and the assembly lead time that are affected by the decision need to be identified and compared to the lead time of ordering and receiving the module from the supplier. Hence, in the case of considering outsourcing, it is necessary to receive offers from suppliers in order to estimate the lead time for ordering and receiving the specific module. When conducting this comparison it is important to remember that even if the lead time for a call off article can be reduced, it will not have an effect on the total lead time towards the end customer unless all other call off articles have shorter lead times. In more detail, it is the time from ordering the call off articles until the assembly of the rig is completed that is of interest in this investigation, as this time is the shortest possible lead time that SED can produce a customer order. When reducing part of the total assembly time, however, it will directly impact the total lead time towards the customer. Thus, both the changes in lead time for the call of articles as well as the assembly time of the specific modules need to be assessed together in order to determine the final effect on the total lead time in the case of in-house production. In order to aid the process of evaluating these aspects of time, specific questions have been formulated for the respective scenarios. As the modules differ depending on what rig model they are part of and what options the customers require, almost every module is unique. When making this analysis it might hence be convenient to choose a representative module variant in order to facilitate the lead time calculation. Starting with the case of considering an outsourcing setup, the following questions need to be considered:

- What is the actual lead time of assembling the considered module in-house?
  - What call of articles, if any, are included in the considered module?
  - What is the lead time from ordering to receiving these articles?
  - What is the assembly lead time of the module?

- What lead time, from ordering to receiving, of the module which is considered is offered by the supplier?
  - Will the time from ordering call off articles until the assembly of the rig is completed be affected if this module is produced by an external supplier? In that case, how many days?

Secondly, in the case of considering the transfer of a module to the internal production, the questions below should be assessed:

- What is the actual lead time, from ordering to receiving, of the module which is considered?
- What is the estimated lead time of assembling the considered module in-house?
  - What call of articles, if any, are included in the considered module?
  - What is the estimated lead time from ordering to receiving these articles?
  - What is the estimated assembly lead time of the module?
  - Will the time from ordering call off articles until the assembly of the rig is completed be affected if this module is produced in-house?

6.3.6 How to decompose and measure quality

Quality is a very broad and complex concept and, as stated in the theoretical framework, there are numerous of definitions of this specific parameter. However, this is not an obstacle but rather favorable,
according to Reeves and Bednar (1994) who conclude that the quality definition at a specific firm should be determined out from the corporate context, why a generic and global definition is inadequate. Still, the different definitions all include that quality encompasses the measurement of how well customer requirements are met or exceeded.

Furthermore, how SED defines quality and how the required quality is specified in the supplier contract is a determinant factor of what quality that is received, if part of the assembly is chosen to be transferred to an external supplier. Consequently, the more complex and knowledge intensive the specific module is, the more important it is to, in an accurate way, specify the quality in the agreement with the supplier. This process will generate costs which will be included in the transaction cost parameter. As these requirements are the foundation for the quality that is received, and as no lower degree of quality is acceptable, the quality of the product is not dependent on the setup of the make-or-buy decision. Hence, unless the quality criteria can be fulfilled, there will be no collaboration with an external supplier and similarly it is not acceptable if the internal production should fail to live up to the quality requirements. Meeting the quality requirements is thus a necessity, whether the products are produced in-house or externally. Therefore, there is no need to include the quality parameter as a standalone parameter in the make-or-buy decision model. Nonetheless, this does not imply that the quality requirement should be neglected but rather it is a crucial criterion that always should be fulfilled, regardless of the decision.

However, there is always a risk that the quality requirements are not met, why regular inspections of incoming goods and quality verification processes need to be performed, in line with Setterwall (2013). At SED, these inspections and processes are necessary regardless of whether the products are produced externally or internally. Furthermore, as van Weele (2010) state, it is not primarily the quality that generates costs, but rather the lack of quality. If there are quality shortages which in the end affect the end customer on the field, the firm may lose its sustainable advantage which will be a devastating and costly scenario, in line with Seyedhosseini et al (2012). The risk for these shortages in quality can be linked to either opportunistic behaviour by the supplier or unintentional deficiencies in the production, which will be further discussed in the parameter risk. Furthermore, the time it takes to inspect the arriving goods, in order to avoid this scenario, is affecting the material handling costs, why this will be further discussed under the cost parameter.

6.3.7 How to decompose and measure risk
According to Aron et al (2005), risk can be classified in the different categories strategic, operational, loss of knowledge and location risk. Strategic risk is associated to opportunistic behaviour while operational risk relates to unintentional breakdowns in the vendor’s operations (ibid). These breakdowns or complications can be an effect of limited knowledge at the supplier. Abrahamsson et al (2003) support this and further state that this risk needs to be considered when facing a make-or-buy decision. The strategic and operational risks thus describe different aspects of risk that are relevant to consider when making the make-or-buy decision. Furthermore, the risk of losing internal knowledge is the general risk that results from transferring an activity to an external supplier. Ritchnér and Rognes (2013) agree on this and state that the risk of losing competence, as also were identified in the section regarding access of knowledge and resources as well as flexibility, needs to be considered before the make-or-buy decision is made.

Furthermore, Abrahamsson et al (2003) identify additional aspects of risk by dividing it into the risk categories too dependent on supplier, imitation and minimized competitive advantage, loss of core competence, loss of value enhancing processes and limited ability to transform. The first aspect, too dependent on supplier, is significant to consider at SED as they are highly dependent on their suppliers to deliver according to plan, communicate well and adapt required changes. Similarly, the location risk, according to Ritchner and Rognes (2013) definition, includes obstacles due to cultural or language related differences that may cause communication problems and is thus relevant to consider. Furthermore, as
SED acts in a competitive market with competitors that try to imitate their products, it is important for potential suppliers to act in confidentiality. Furthermore, the aspect of core competence and loss of value enhancing processes are central aspects of the make-or-buy decision. However, as these aspects already have been discussed in the parameter core competence, where methods for proactively avoiding these risks have been identified, it will not be discussed any further in this section. Finally, the risk of having a limited ability to transform the internal operations in response to transferring an activity to an external supplier is closely connect to the cost parameter as this scenario will result in double costs. Therefore, this aspect will be discussed in the section regarding costs.

In addition to these aspects, Malmgren (2010) identifies a range of risks including decreased quality, legal problems, loss of control, low adaption of new technology by the supplier and a decrease in customer satisfaction due to lack of business knowledge attained by the supplier. Beginning with the risk of a decrease in quality, this matter has been treated in a separate section and will thus not be included here. Furthermore, the risk of having legal problems is another risk that needs to be considered before the make-or-buy decision can be made. The risk category loss of control highlights an additional aspect of risk that exist both when in- and outsourcing part of an activity. In more detail, Vining and Globerman (1999) state that the control is not necessarily higher when a specific activity is performed in-house. This aspect is relevant to consider when conducting the make-or-buy decision at SED and will thus be include in the model. Continuing with the next risk, low adaption of new technology by the supplier, this risk is rather specific and can be included in Abrahamsson et al's (2003) more general category, namely the risk of becoming too dependent on a supplier. The reason for this is that if the supplier is unwilling or unable to adapt new technology, it may cause complications at SED.

Moreover, McCormack (2010) defines risk by dividing it into the different aspects operational risks, network risks and external risks. These aspects, however, have already been included in the previous identified risks. Similarly, Das and Teng’s (2011) definition of relational risk is closely related to both the strategic and location risk. Thus, as relational risk is a broader concept, that include both the risk of opportunistic behavior as well as unsatisfactory supplier collaboration, this parameter will be used instead of strategic and location risk. Furthermore Das and Teng’s (2011) definition of performance risk relates to all other risks, apart from the supplier relation, that can occur. This risk is thus too broad and unspecific to contribute with any additional information. Nevertheless, one aspects of risk that have not been included in the model is the possibility to reduce risk by sharing as stated by van Weele (2010). By summarizing the aspects of risk that will be represented in the make-or-buy decision model, the, following sub-parameters are obtained:

- Relational risk
- Operational risk
- Loss of knowledge
- Too dependent on supplier
- Imitation by competitors
- Legal risk
- Loss of control
- Possibility to reduce risk by sharing

Furthermore, apart from the above stated risks there may be additional and context specific risks that are relevant to consider in the make-or-buy decision. Therefore, when making the risk analysis, the above stated sub-parameters of risk should be supplemented according to the specific situation.

In order to measure these risks, the method that Ball and Watt (2013), among many authors, describe can be implemented. This method includes an estimation of the likelihood and consequence of a risk. Hence
Table 4: Evaluation of risk by estimating likelihood and consequence

In order to aid the process of assessing the strategic aspects of risk, it can be useful to evaluate if there has been a problem with opportunistic behavior, historically. Thus, previous collaborations with suppliers may give an indication of how likely this risk is to occur. Similarly, by analyzing the market environment and the power balance relation between SED and the potential supplier further signals of how likely this risk is to occur can be obtained. Furthermore, when considering the transfer of a module to an external supplier, it is also relevant to investigate whether there is any reason to fear that the distance may cause any problems such as language or cultural barriers. The following questions are thus useful to keep in mind:

- **What is the likelihood and consequence of the relational risk?**
  - Is there any reason to fear that the supplier will act opportunistic, based on prior collaborations?
  - Does the supplier act in a competitive or monopolistic market environment?
  - How is the power balance relation, between SED and the considered supplier?
  - Is there any reason to fear that the distance, or eventual country barriers, to the supplier will invoke a problem?
  - Are there any cultural or language related differences that may cause communication problems?
  - What is the outcome if the considered risk should occur?

Furthermore, when considering the transfer of an activity to an external supplier, an indication of how likely it is for breakdowns at the vendors operations can be obtained by assessing previous collaborations. Similarly, if key performance index are available, these might also be useful in order to make a qualified guess. Other aspects that are relevant to investigate in order to assess the operational risk is how updated the supplier’s equipment and technology is and what competence level they obtain. Thus, the following questions have been formulated in order to aid the evaluation of the operational risk:

- **What are the likelihood and consequence of the operational risk, at the external supplier?**
  - Is there any reason to fear that breakdowns will appear at the supplier’s operations, based on prior collaborations?
  - Is any key performance index attainable? If yes, does the statistics indicate that there are reasons to fear breakdowns at the vendors operations and quality shortages?
Objectives

- How updated is the supplier’s production equipment?
- Does the supplier collaborate with any market-leading firms that are acknowledged as competent?
- What competence and knowledge level are present at the supplier, based on educational level and prior experience?
- What is the outcome if the considered risk should occur?

Similarly, when considering the transfer of an activity to the internal production, it is relevant to investigate how likely it is for breakdowns in-house. Hence, the following questions are relevant to consider:

- What are the likelihood and consequence of the operational risk in-house?
  - Is there any reason to fear that breakdowns will appear at SED’s internal operations?
  - Is any key performance index attainable? If yes, does the statistics indicate that there are reasons to fear breakdowns at the vendors operations and quality shortages?
  - How updated is SED’s production equipment?
  - What competence and knowledge level are present at SED, based on educational level and prior experience?
  - What is the outcome if the considered risk should occur?

When a firm transfers activities to an external supplier, it can result in the loss of in-house competence, according to Scherrer-Rathje et al (2014). The authors further argue that it is important that there is an ambition to maintain the same amount of knowledge and access further knowledge through the supplier in order to reduce this risk. With regard to this, it is relevant to investigate if similar task still will be performed in-house, even if the module is transferred to an external supplier. Furthermore, whether the internal staff will be involved in the research and development of the module can also provide an indication of the risk of losing competence. The reason for this is that there is a greater possibility that the knowledge is maintained if the internal staff keeps working with the considered module. Finally, it is also relevant to investigate what level of documentation that is available at SED, as the more documentation that is available, the easier it is to still maintain the knowledge. Hence, in order to evaluate the next sub-parameter of risk, namely the risk of losing knowledge, the subsequent questions can act as a guide:

- How is the risk of losing knowledge affected by the make-or-buy decision?
  - Will the internal staff perform similar tasks, if the considered activity is transferred to an external supplier?
  - Will the internal staff still be involved in the research and development of the considered activity, thus still being part of the manufacturing process?
  - What level of documentation is available for the considered activity?
  - What is the outcome if the considered risk should occur?

Next, the risk of becoming too dependent on the supplier is closely connected to Tan and Sia’s (2006) aspect of flexibility, ease of exit, meaning that when transferring an activity to an external supplier, there is a risk of being locked in that relationship. Furthermore, the authors state that this particularly concerns outsourcing relations where the supplier holds scarce and critical resources. Hence, it is relevant to establish whether the considered activity concerns any scarce and critical resources and, if this is the case, whether SED or the supplier holds them. In addition to this, it is also possible to acquire an estimation of how high the risk of becoming too dependent on the supplier is by investigating prior collaborations. Likewise, it is relevant to establish whether there are any reasons to fear that the supplier is unwilling to adapt new technology or similarly, which may cause problems for SED. With this in mind, the following questions have been formulated to act as a guide when assessing the risk factor of becoming too dependent on the supplier:
• What are the likelihood and consequence of the risk to become too dependent on the supplier?
  ➢ Does the considered activity concern scarce and critical resources?
  ➢ Has any previous collaboration generated problems due to SED being too dependent on the supplier, historically?
  ➢ Is there any reason to fear that the supplier is unwilling or unable to adapt new technology or make other investments?
  ➢ What is the outcome if the considered risk should occur?

Continuing with next parameter, imitation by competitors, this refers to the risk of losing sensitive information to competitors. In order to estimate this risk it is therefore relevant to assess whether the supplier is confidential and whether it is necessary to share sensitive information with the supplier. Thus, the following questions can be used as an aid:

• What are the likelihood and consequence of the risk that competitors will imitate internal operations, which can result in loss of competitive advantage?
  ➢ Is there any reason to fear that the supplier lack the ability to be confidential?
  ➢ Is it necessary to share critical knowledge and information with the supplier, in the considered make-or-buy setup?
  ➢ What is the outcome if the considered risk should occur?

Furthermore, in order to assess the legal risk, it is necessary to evaluate the specific laws and regulations of the country that the considered supplier is established in. Hence, it is possible to make a qualified guess how likely it is that there will be any legal problems related to the collaboration. In addition to this, this risk can also be estimated by analyzing historical collaborations at SED, and whether any of these involved legal complications.

• What are the likelihood and consequence of legal risk in the considered make-or-buy setup?
  ➢ Has any previous collaboration involved legal problems, historically?
  ➢ In which country is the potential supplier located?
  ➢ What is the outcome if the considered risk should occur?

Next, in order to assess the risk of losing control, it is relevant to investigate how the ability to exert control will be affected by the considered make-or-buy setup. In order to do this, the power balance between SED and the considered supplier may give an indication of how eager the supplier is to satisfy SED’s requests. Similarly, when evaluating the risk of losing control in-house, it is relevant to investigate whether there are clear instructions and incitements that minimize the risk of losing control. Thus, the following questions are relevant to keep in mind:

• What are the likelihood and consequence of the risk to lose control, in the considered make-or-buy setup?
  ➢ Is it likely that the risk of losing control will increase when implementing the considered make-or-buy setup?
  ➢ How is the power balance relation, between SED and the considered supplier?
  ➢ Are there clear working instructions at SED?
  ➢ Are there incitements for following these instructions?
  ➢ What is the outcome if the considered risk should occur?

Finally, there is also a possibility to reduce risks by sharing them. One method for doing this is by avoiding investments in new technology, or similarly, by letting the supplier stand for these. Likewise, it might be possible to reduce other risks, such as increased prices on raw materials, by sharing them with the supplier. In contrary to this, when transferring an activity to the internal production, there is a risk that some risks that have previously been shared with an external supplier might increase. In order to assess this aspect, the following questions have hence been formulated:
• Is it possible to reduce any risks by sharing them?
  - Does collaboration with an external supplier enable SED to avoid investments in any technology or equipment?
  - Is it possible to reduce any other risks by sharing them with the supplier?
  - Is it likely that any risks will increase, if the considered module is transferred to the internal production?
  - What is the outcome if the considered risk should occur?

6.3.8 How to decompose and measure costs

In order to evaluate the actual cost, all cost parameters that are affected by a changed make-or-buy setup need to be considered. Oskarsson et al (2013) suggests that a total cost analysis can be used when a firm faces a change within its logistic structure, as this approach evaluate the affected costs in the entire organization, not only the departments which are obviously related to the change. Furthermore, if efforts are made to reduce costs in one single and isolated area, instead of taking the total cost approach, reduction of one cost may drive up costs in another area of the logistics system, according to Lambert et al (1998). Therefore, the total cost analysis approach will be used. Furthermore, in the cases where there are over-head costs that need to be broken down, activity based costing can act as a supporting tool in order to be able to measure the cost changes.

Furthermore, Ellram and Maltz (1995) stress that it is only relevant to include the parameters of cost that are affected by the decision. Thus, the costs that remain unchanged by the make-or-by decision are not interesting to assess. Moreover, as the make-or-buy decision is highly context specific, it necessary to adapt the cost model to the particular situation, in line with Oskarsson et al (2013). This is supported by Ellram and Maltz (1995) who further argue that each make-or-buy decision is unique and therefore should be evaluated individually. Hence, when selecting sub-parameters that should be included in the cost parameter, these aspects will be taken into consideration.

Oskarsson et al (2013) suggest that the following parameters should be considered when evaluating a logistic change: inventory carrying costs, warehousing costs, transportation costs, administrative costs and additional logistic costs. Inventory carrying costs are related to the cost of having tied up capital and are important to include in a cost assessment as the make-or-buy decision at SED will affect this parameter. Similarly, warehousing costs, which refer to costs associated with keeping the storage, are also important to consider at SED. However, this cost parameter will be referred to as material handling costs as it is also of interest to include the cost for receiving and inspecting the arriving goods. Similarly, the total transportation cost will also be affected by the decision and is thus relevant to include in the model. However, as the transport to the end customer will remain unchanged it is only the cost of transporting articles or complete modules to the firm that are relevant to investigate.

Furthermore, the parameters administrative costs and additional logistic costs are rather general and thus need to be specified in order to be useful in the model. Beginning with administrative costs, this is defined as the costs of administrating the make-or-buy setup, including planning and ordering of material. This parameter can thus be connected to Ellram and Maltz (1995) parameters of management and communication. As several of functions are involved with administrating the manufacturing process, which results in large costs, this parameter is necessary to include when evaluating the effect of the make-or-buy setup on cost. Continuing with the next parameter, however, there are no additional logistic costs that are relevant to consider at SED and therefore this parameter will not be included.

Moreover, another parameter that is relevant to include in the make-or-buy decision at SED is manufacturing cost. In more detail, it is the specific manufacturing cost of the considered product or module that is of interest. In addition to this, if the supplier will be involved in the research and development function, it is also necessary to include this added cost. As this cost is connected to the manufacturing of the product it will be included in the parameter manufacturing cost.
According to Vining and Globerman (1999), it is also of interest to include bargaining and opportunistic costs when evaluating an outsourcing decision. These costs are commonly referred to as transactions costs and include the cost of maintaining a relation with the external supplier, negotiation, writing and updating contracts as well as costs that arise due to opportunistic behaviour. Depending on how complex the considered module is and the choice of supplier, the extent of the transactions costs vary. Moreover, as this cost is affected by the make-or-buy decision, and thus may have an impact on which decision that is most advantageous, it will be included in the model.

By summarizing the cost sub-parameters that will be included in the make-or-buy decision model the result is thus as follows:

- Inventory carrying costs
- Material handling costs
- Transportation costs
- Administrative costs
- Manufacturing costs
- Research and development costs
- Transaction costs

The next step is to determine how the above stated sub-parameters can be measured. Furthermore, in order to successfully identify these sub-parameters for production of a specific module, it may be necessary to break down over-head costs. However, as identified by Abrahamsson et al (2003), there is a risk of being unable to transform the internal operations after the decision, which may lead to double costs. With regard to this, it needs to be assured that the identified differences in the cost parameters really can and will be achieved.

Beginning with inventory carrying costs, these are determined by which and how many articles that are kept in storage, the value of these, how long they are kept in storage and the inventory interest at SED. In order to determine this, it is necessary to also include any safety margins that might be stored. Furthermore, the value of the respective stored articles corresponds to the parameter standard cost, which is available in the ERP-system at SED. The assessment of the inventory carrying costs for the current and the considered make-or-buy setup can thus be facilitated by using formula 1 below. As previously mentioned, almost every module is unique and hence it might be convenient to choose a representative module variant in order to facilitate the cost calculation.

**Formula 1:** \[ \text{Inventory carrying costs} = \text{Avarage stock level} \times \text{Std. cost} \times \text{Inventory interest} \]

When buying a module from an external supplier, the average stock level thus depends on how many days the considered module is stored before it is used and when SED starts owning the module. Furthermore, the standard cost is in this case equivalent to the standard cost of the module and the inventory interest refers to SED’s inventory rate. When assembling the considered module in-house, however, the average stock level is evaluated by determining which articles that are kept in storage, how long every article is kept in storage and the safety stock level of these articles. The average stock level also includes any possible call of articles that are included in the module and how long these are kept in storage before they are used in the production. Similarly, if the whole module is stored before it is used in the final assembly, this also needs to be taken into account. Furthermore, in the case of assembling the module in-house, the standard cost in formula 1 above refers to the standard cost of all the respective articles that are kept in storage. The inventory interest, however, still refers to SED’s fixed inventory rate.

Moreover, it is also worth mentioning that if the cost of buying the module is different from the cost of buying the respective articles and assembling the module in-house, this will result in a different processed value. According to Oskarsson et al (2013) the processed value corresponds to the value of products that are in the production flow. The value of these is thus increased successively, as work is put in to refine the
products (ibid). With regard to this, the value of the complete module will differ, which will have an impact on the processed value of the rigs that are produced.

In order to facilitate this cost assessment, the questions stated below need to be considered:

- In the case of considering transferring an activity to an external supplier, how will the inventory carrying costs be affected?
  - What is the current inventory carrying cost for the considered module and its respective articles?
  - How high are the inventory carrying costs estimated to be when buying the module from an external supplier?
  - How will the processed value of the complete rig be affected?

- In the case of considering transferring an activity to the internal production, how will the inventory carrying costs be affected?
  - What are the current inventory carrying costs when buying the considered module from an external supplier?
  - What are the inventory carrying costs estimated to be if the considered module is assembled in-house instead?
  - How will the processed value of the complete rig be affected?

- What is the inventory carrying rate?

Furthermore, in order to assess how the material handling costs are affected by the make-or-buy decision, it is necessary to break down the overhead costs. This includes the cost for the employees at the warehouse, the trucks, the storage area and other costs related to keeping the storage. Additionally, the costs for receiving and inspecting the arriving goods need to be included as well. Moreover, in the case of transferring an activity to an external supplier, it may not be possible to lower the material handling costs even if the total number of stored and managed articles is reduced. Similarly, it might be possible to handle a larger number of articles with the existing material handling resources, in the case of transferring an activity to the internal production. Thus, the following questions are necessary to consider:

- In the case of considering transferring an activity to an external supplier, how will the material handling costs be affected?
  - What is the current material handling cost for the considered module and its respective articles today?
  - Is it possible to reduce the material handling costs if the module is transferred to an external supplier?

- In the case of considering transferring an activity to the internal production, how will the material handling costs be affected?
  - What is the current material handling cost for the considered module today?
  - Is it necessary to increase the storage space, number of handled articles, warehouse employees or similarly when transferring the module in-house, which will increase the material handling costs?

In order to evaluate how the transportation costs are affected, the cost for transporting the whole module from an external supplier needs to be compared to the cost of supplying all articles included in the module to SED from their respective suppliers. Furthermore, in the case of considering outsourcing, it might be necessary to send quotations to potential suppliers and receive offers in order to successfully estimate the transportation costs. Thus, the following questions need to be evaluated:

- In the case of considering transferring an activity to an external supplier, how will the transportation costs be affected?
  - What is the current transportation cost for transporting the articles that are included in
the module to SED?

- What is the estimated cost for transporting the whole module to SED?
- In the case of considering transferring an activity to the internal production, how will the transportation costs be affected?
  - What is the current cost of transporting the module to SED?
  - What is the estimated cost for transporting all the articles that are included in the module, from their respective suppliers to SED?

Continuing with the administrative costs, it is necessary to estimate if an increase or decrease in these can be implemented. As previously discussed, even if an increase or decrease in the workload is experienced it is possible that the number of employees, and hence the costs, will remain unchanged. Thus, the following questions need to be assessed:

- Which administrative operations are affected by the make-or-buy decision?
- In the case of considering transferring an activity to an external supplier, is it possible to decrease the administrative costs?
  - What is the estimated change in time for ordering and managing the module?
- In the case of considering producing the considered module in-house, will the administrative costs increase?
  - What is the estimated change in time for ordering and managing the articles included in the module?

Furthermore, it is also necessary to assess how the manufacturing costs are affected by the decision. Thus, in the case of transferring an activity to an external supplier, the estimated price of the considered module needs to be estimated and compared to the current manufacturing costs of the module. Similarly, when considering transferring an activity to the internal production, the new manufacturing cost, including material cost, needs to be estimated and compared to the current cost when buying from the supplier. Furthermore, in order to correctly assess the price of the module when buying from an external supplier it is necessary to receive offers from potential suppliers. The following questions have thus been formulated to aid the assessment of the manufacturing costs:

- In the case of considering transferring an activity to an external supplier, how will the manufacturing costs be affected?
  - What is the current production cost for assembling the module in-house?
  - What is the estimated cost for buying the module from an external supplier?
  - Is it possible to achieve economies of scale in the internal production, by transferring the considered activity to an external supplier?
- In the case of considering transferring an activity to the internal production, how will the manufacturing costs be affected?
  - What is the current cost when buying from an external production?
  - What is the estimated cost for assembling the module in-house, including material costs?

Additionally, the research and development costs are also relevant to investigate when making the total cost analysis. Hence, in the case of outsourcing, it needs to be determined whether the supplier will be involved in the research and development operations of the considered module. If this is the case, this cost needs to be estimated and compared to the current costs for the research and development operations. In order to successfully estimate the cost of involving the supplier in the research and development operation, it might thus be necessary to receive offers from potential suppliers where this cost is specified. Furthermore, when considering transferring the assembly of the considered module in-house, the cost for research and development needs to be included in the cost analysis if the supplier is currently involved in this operation. To clarify, if the current supplier is not involved in the research and development, these costs will remain unchanged even if the module is transferred to the internal
production. Thus, in this case, there is no need to include these costs in the total cost analysis. If, however, the current supplier is involved in the research and development function, it needs to be assessed if the internal research and development costs will increase in the case of internal production.

- In the case of considering transferring an activity to an external supplier, how will the research and development costs be affected?
  - Will the external supplier be involved in the research and development function and, in that case, what is the estimated cost for this?
  - Is it possible to decrease the internal cost for the research and development function by transferring part of the responsibility to the external supplier?
- In the case of considering transferring an activity to the internal production, how will the research and development costs be affected?
  - What is the current cost for involving the supplier in the research and development function?
  - Are the internal costs for the research and development function expected to increase?

Finally, it is also necessary to evaluate how the transactions cost are affected by the decision. This include bargain, writing technical specifications, signing contracts and the cost for eventual opportunistic behaviour. These costs are related to the outsourcing decision and when transferring an activity to the internal production these costs are expected to decrease. In contrast, when transferring an activity to an external supplier, these costs will increase due to managing an additional supplier relation. The following questions are thus relevant to consider:

- In the case of considering transferring an activity to an external supplier, how will the transaction costs be affected?
  - How is the supplier base affected by the considered option?
  - What is the estimated change in time for bargaining and managing the supplier relation for the considered option?
- In the case of considering transferring an activity to the internal production, how will the transaction costs be affected?
  - How is the supplier base affected by the considered option?
  - What is the estimated change in time for bargaining and managing the supplier relation for the considered option?

In order to assess the extent of these costs, Vining and Globermann’s outsourcing matrix can be used as a tool.

### 6.4 Priority of selected parameters

The next research question concerns how the parameters should be prioritized and the procedure for answering this question is through an adapted version of the analytical hierarchy process. Firstly, the parameters were compared in pairs, where they received a score based on the importance of the parameter in the make-or-buy decision. Thereafter, these scores were summarized for each parameter and normalized in order to be able to finally receive a priority. In order to obtain a result that is as objective as possible, individual opinions were not taken into consideration but instead the focus was on the general interest of the firm. Thus, the sub-parameters will be compared, independently of the main-parameters, based on how important they are to SED’s operations as well as the impact they have on the outcome of the make-or-buy decision. When comparing the cost parameters, regard will be taken to how central the respective cost parameters are to the make-or-buy decision. That is, to what extent they will be affected.

When conducting the pairwise comparison, the result that can be seen in table 5 below was obtained. As the scores were normalized, the total sum of the scores is equal to 23 which correspond to the number of
investigated parameters. As illustrated in the table, core competence, with a score on 3.86, is clearly highlighted as the most important parameter to consider in the make-or-buy decision. Next, the parameters volume flexibility, inventory carrying costs, manufacturing costs and lead time were also identified as parameters with significantly high scores that range from 1.87 – 1.94. Regarding the rest of the parameters, they range from the score 0.29 – 0.93.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Score</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core competence</td>
<td>3.86</td>
<td>1</td>
</tr>
<tr>
<td>Inventory carrying costs</td>
<td>1.94</td>
<td>2</td>
</tr>
<tr>
<td>Volume flexibility</td>
<td>1.92</td>
<td>3</td>
</tr>
<tr>
<td>Manufacturing costs</td>
<td>1.91</td>
<td>4</td>
</tr>
<tr>
<td>Lead time</td>
<td>1.87</td>
<td>5</td>
</tr>
<tr>
<td>Transportation costs</td>
<td>0.93</td>
<td>6</td>
</tr>
<tr>
<td>Administrative costs</td>
<td>0.88</td>
<td>7</td>
</tr>
<tr>
<td>Transaction cost</td>
<td>0.85</td>
<td>8</td>
</tr>
<tr>
<td>Warehousing costs</td>
<td>0.82</td>
<td>9</td>
</tr>
<tr>
<td>Relational risk</td>
<td>0.82</td>
<td>10</td>
</tr>
<tr>
<td>Time flexibility</td>
<td>0.78</td>
<td>11</td>
</tr>
<tr>
<td>Long term capacity</td>
<td>0.76</td>
<td>12</td>
</tr>
<tr>
<td>Too dependent on supplier</td>
<td>0.73</td>
<td>13</td>
</tr>
<tr>
<td>Improved R&amp;D operations</td>
<td>0.70</td>
<td>14</td>
</tr>
<tr>
<td>Acquiring competitive knowledge</td>
<td>0.63</td>
<td>15</td>
</tr>
<tr>
<td>Loss of knowledge</td>
<td>0.62</td>
<td>16</td>
</tr>
<tr>
<td>Imitation by competitors</td>
<td>0.58</td>
<td>17</td>
</tr>
<tr>
<td>Loss of control</td>
<td>0.49</td>
<td>18</td>
</tr>
<tr>
<td>Operational risk</td>
<td>0.48</td>
<td>19</td>
</tr>
<tr>
<td>R&amp;D cost</td>
<td>0.45</td>
<td>20</td>
</tr>
<tr>
<td>Product flexibility</td>
<td>0.39</td>
<td>21</td>
</tr>
<tr>
<td>Legal risk</td>
<td>0.33</td>
<td>22</td>
</tr>
<tr>
<td>Possibility to minimize risk by sharing</td>
<td>0.29</td>
<td>23</td>
</tr>
</tbody>
</table>

Table 5: Priority of the selected sub-parameters

Furthermore, these scores aim to solely give an indication of the priority of the sub-parameters. Therefore, the result should not be followed blindly but rather be used as guidance when constructing the first draft of the decision model.

6.5 Determination of knockout criteria

Finally, the last research question in this stage, RQ4, is whether any sub-parameter is a knockout criterion. In order to determine this, the method is to evaluate whether any of the sub-parameters is regarded as
prerequisites, either at SED or according to contemporary academic findings.

When reviewing the theoretical framework, the prerequisites core competence is identified. Furthermore, when prioritizing the parameters in RQ3, core competence was ranked as much more important than the rest of the parameters. At SED, this aspect has also been emphasized as determinant for the make-or-buy decision. This implies that, regardless of the outcomes of the other parameters, it will never be motivated to outsource part of an activity that is classified as core competence. Thus, as a careful evaluation of core competence is highlighted as a prerequisite, at SED as well as in contemporary academic findings in order to make an appropriate decision, it can be considered as a knockout criterion.

Furthermore, the parameters cost, lead time and volume flexibility were also highly ranked when prioritizing the parameters. Unlike core competence, however, these parameters are measured on a scale and are not a yes or no answer. Each of these parameters can thus be viewed as an individual knock out criterion, with a specific limit that sets the boundary for what level that is acceptable or not. Furthermore, as these parameters are all highly significant for the make-or-buy decision, it is also relevant to investigate these parameters collectively. The reason for this is that even if none of the parameters exceed the set limit, it may still not be necessary to continue with the investigation if none or very little benefits can be achieved. Thus, it is relevant to investigate these parameters both individually and collectively and if the pre-set conditions are not fulfilled, there is no need to continue with the investigation. Similarly, the risk parameters will also be viewed both individually and collectively. Hence, if either an individual risk or the collective risk is assessed as too high, it is irrelevant to continue with the investigation.

When making the first draft of the decision model it is hence necessary to determine the limit for each of the individual and collective criteria. This will be further evaluated in the next section, decision model 1.
7 First draft of the make-or-buy decision model

In this chapter, the first draft of the make-or-buy decision model will be constructed. This will be executed based on the result generated from the previously evaluated research questions. To start with, the general structure of the model will be presented. Thereafter, each step in the decision model will be described in more detail.

7.1 General structure

When using the decision model the user will provide the input, which means that the user needs to have an idea of what module that is of interest to evaluate. Hence, if the considered module is produced in-house, the model will act as an aid to help determine whether it is more beneficial to buy the module from an external supplier instead. Similarly, if the considered module is currently produced by an external supplier, the alternative of internal production will be investigated and compared to the current setup. Furthermore, although the term module is used to facilitate for the reader, the decision model will also be used in order to evaluate whole products or smaller sub-assemblies as well. Additionally, even if a module is transferred to the internal production or the other way around, this does not necessarily mean that all assembly operations are executed by the same party. For example, a possible scenario could be that the supplier assembles the standard module while SED is in charge of the options. The end-user is thus responsible for providing this input when using the decision model.

Based on the result that was obtained when prioritizing the sub-parameters and evaluating which parameters that can be regarded as knockout criteria, aid can be given when constructing the first draft of the decision model. As illustrated in the priority of the sub-parameters, to ensure that the core competence is kept in-house is highly significant when making the make-or-buy decision. Furthermore, it was also determined that this sub-parameter is a knockout criterion. Hence, the first step in the decision model is to evaluate if the considered module can be categorized as core competence or not, as can be seen in figure 17 below. This is supported by Kumar et al (2010) who argue that the evaluation regarding if the considered activity is core competence or not should be the first step of the decision process. If this is the case when evaluating an outsourcing setup, there is thus no need to fulfil the rest of the investigation, as it will never be motivated to transfer part of a core activity to an external supplier. Similarly, it is relevant to investigate if it is possible to still remain focus on core competence if an additional operation is transferred to the internal production.

Continuing with the list of prioritized sub-parameters, volume flexibility, lead time, inventory cost and manufacturing cost, were also identified as parameters with high scores. However, in order to evaluate these, it is necessary to send out request of quotations to potential suppliers before this evaluation is initiated. How this should be conducted will not be further investigated, as SED already has a suitable process for this procedure. Thus, before the parameters are evaluated a supplier evaluation is necessary which is illustrated in figure 17 below. As previously discussed, each of the parameters volume flexibility, lead time and the sub-cost parameters have a limit for what can be accepted in order to motivate a further investigation of the considered setup. Additionally, as these parameters are closely followed by the rest of the cost parameters, in the prioritized list of sub-parameters, and as it is advantageous to evaluate all costs that are affected by the change collectively, according to the total cost analysis approach, all cost parameters will be evaluated together. Furthermore, as the parameters volume flexibility, lead time and the total cost are of high importance, it is desirable to achieve an improvement in all of these aspects. Nonetheless, in some instances it may still be relevant to continue with the investigation even if one or two of the parameter remains unchanged or is deteriorated, given that the third parameter is improved. With regard to this, these parameters will be evaluated collectively as well, in order to determine if it is relevant to continue the investigation.
Furthermore, the sub-parameter strategic risk is next on the prioritized list of parameters. Hence, the next step in the make-or-buy decision model is to evaluate this risk. In order to facilitate the procedure, the remaining risks will be analyzed at the same time which is also motivated by the fact that the remaining risk parameters received similar scores in the priority list. If this assessment indicates that the risks exceed the predetermined limit, and if these risks cannot be easily reduced, it is not relevant to continue with the investigation. This is illustrated in figure 17 below.

Regarding the remaining parameters, these were ranked as less important than the other parameters. Hence, if the previously investigated parameters clearly indicate that the considered make-or-buy setup is more advantageous than the current setup, these parameters will not have an impact on the outcome. However, in that case, it is still useful to evaluate these additional parameters as they will contribute to further insights regarding the implementation. Moreover, if the previously investigated parameters have resulted in a rather ambivalent outcome, the remaining parameters will have an impact on the final decision. This is illustrated in figure 17 below.

Figure 17: General structure of the first draft of the make-or-buy decision model
7.2 Detailed description
In the following sections a detailed description of how the respective steps in the make-or-buy decision model should be conducted will be presented.

7.2.1 Step 1: Evaluation of core competence
As illustrated in figure 17 above, the first step of the make-or-buy decision model is to determine whether the module or part of module, which is under investigation, can be considered as core competence at SED or not. More specifically, as it is stated by Quinn and Hilmer (1995), a product or function cannot be categorized as a core competence. Therefore, it is the activity, and the associated skills and knowledge, that generates the module that is of interest in this step in the model. In figure 18 below, an illustration of the more detailed methodology of the execution of this step can be seen. The analysis is initiated when a make-or-buy question has been raised at the firm. Furthermore, when the evaluation of core competence has been finalized, the make-or-buy investigation is either terminated or continued based on the obtained result. In more detail, if the considered module is classified as core competence, the investigation is terminated. If the considered module is not classified as core competence, however, the investigation continues with an investigation of lead time, volume flexibility and risk.

Figure 18: Detailed description of how to evaluate core competence

When the activity that generates the module, with associated skills and knowledge, is identified, the first step within the core competence evaluation, illustrated as step 1a in figure 18 above, can be performed. Here, it is determined if the considered activity can be classified as core competence by answering the questions, with respective sub-questions, in section 6.3.1. If yes is the answer to all the stated questions, then the investigated competence or activity can be considered as a core competence and consequently the make-or-buy investigation can be terminated. Moreover, the current production setup is further recommended. In the cases where there are sub-questions, these also need to be positively answered in order to define the considered competence or activity as company core.

If any of the questions in section 6.3.1, however, gives a negative answer, the assessment need to proceed to the next step, illustrated as step 1b in figure 18 above. In this step, it is determined if the
activity can be classified as a close core activity and therefore need to be kept in-house. In order to execute this investigation, the question and sub-questions listed in section 6.3.1 need to be considered. If all these questions are positively answered, the activity which is under investigation should not be entrusted an external supplier, despite the fact that it is not classified as a core competence. Instead, internal execution is recommended in order to avoid the risk of defining the firm’s core competences to narrowly, and outsource an activity that will cause complications for the main business. Furthermore, if the result of this investigation indicates that the considered activity is a close core activity, the make-or-buy assessment is terminated.

If there are any ambiguities when answering the previous stated questions in this first step of the make-or-buy decision model, step 1c should preferably be executed, as illustrated in figure 18 above. This is also recommended if the questions have been hard to evaluate. In more detail, this step includes a supportive investigation of what is seen as the industry’s most important competences and capabilities by different stakeholders, such as customers, competitors and industry experts. By conducting this investigation, a more accurate view of the firm’s core competence can be obtained. However, as this investigation may be highly time-consuming, it is an optional stage in the model. In order to facilitate the external investigation of what activities that can be classified as core competence, according to the industry’s stakeholder, the question in section 6.3.1 can act as a guide.

Finally, if it is determined that the considered activity is neither a core competence nor a close core activity, the next and last step in the core competence assessment step should be initiated. This step, illustrated as step 1d in figure 18 above, aims to give an indication of whether there is enough value adding activities left in-house or not. In section 6.3.1, questions that will support this evaluation are listed.

If these investigations indicate that the considered activity is neither core competence nor a close core activity, and that enough value adding activities are kept in-house, then the user of the model should proceed to step 2. Otherwise, the assessment is terminated, and the current make-or-buy setup is further recommended. Moreover, when conducting this evaluation of core competence it is important that several of employees from different functions participate. The reason for this is to minimize the risk of a bias result.

7.2.2 Step 2: Sending out request of quotation
The next step in the decision model is to send out request of quotations to two or more potential suppliers. This should be done in order to receive input that can be used to make a qualified analysis of what decision that is most advantageous. In specific, it is necessary to gain input from the suppliers in order to be able to determine which lead time and cost that can be attained by collaborating with an external supplier. If none of the suppliers are interested in collaborating or have the possibility to provide the necessary information that is requested, it is thus necessary to send out requests of quotations to more suppliers. In addition, if several of interesting quotations are received, and if it is hard to assess which of these that is most favorable, several of quotations can be used as input when making the evaluation of the make-or-buy decision.

7.2.3 Step 3: Evaluation of volume flexibility, lead time and total cost
When step 1 and 2 is completed, and if it is determined that further investigation is desirable, step 3 can be initiated. In this step, the parameters volume flexibility, lead time and the total cost effects of the changed setup will be analyzed. In figure 19 below, a detailed description of this third step in the make-or-buy decision model is illustrated.
First, an evaluation of the parameters volume flexibility, lead time and the total cost need to be performed, illustrated as step 3a in figure 19 above. To start with, these parameters need to be individually analyzed and consequently the evaluations can be performed separately and in parallel, in order to make this step more time efficient. However, this is optional and the user of the model can execute these evaluations sequentially, as well, if there are not sufficient resources for a parallel analysis.

In order to evaluate volume flexibility, the questions stated in section 6.3.3 can act as a guide. Nonetheless, a high degree of active participation is required by the end-user in order to estimate the level of volume flexibility of the considered option. In contrast to the evaluation of core competence, there is no strict interpretation of which level an answer to the respective questions generates. Furthermore, when this evaluation is completed, the current volume flexibility level, as well as the estimated volume flexibility level of the considered option is obtained. In more detail, the answers of the below stated questions will give an indication of what level of fluctuations in customer demand that the two evaluated alternatives, the current setup and the investigated setup, is able to manage.

Moreover, the level of volume flexibility is preferable measured in the amount of customer orders of complete drill rigs that SED is able to manage, on a monthly basis, with present capacity and low penalty in time, effort, cost and performance. This conclusion was drawn based on discussions with the supervisor at SED. Specifically, this will generate an upper and a lower limit of number of orders that the current capacity is adapted to. In turn, this gives an interval, x – y, where x is the lowest level of customer orders that SED’s existing capacity is able to manage, and y refers to the upper limit of customer orders. Consequently, it is desirable to expand this interval as much as possible. Furthermore, SED needs to be able to maintain this degree of volume flexibility for a time period of six month in order for this value to be valid.

Secondly, when the lead time evaluation should be performed, the user can be supported by the
questions listed in section 6.3.5. Similarly to the evaluation of volume flexibility, the questions will solely act as a support and the end-user needs to interpret which level of lead time that the evaluation results in. This analysis will generate the actual lead time in the present make-or-buy setup and the estimated lead time of the considered option. Preferably the lead time is measured in the unit “days”.

The last parameter that is evaluated in this third step of the make-or-buy decision model is the total cost. When this evaluation is performed, the total cost analysis approach should be utilized. In order to facilitate this process, the questions in section 6.3.8 can act supportively but the end-user still needs to interpret the answer of the questions. Similarly to the prior evaluations performed in this step, this analysis will take both the present costs, as well as the estimated costs, of the investigated alternative, into consideration. This will enable a deeper understanding for what cost differences the change in make-or-buy setup will generate.

Furthermore, the second step in this investigation, illustrated as step 3b in figure 19 above, includes a determination of whether the evaluated parameters individually adapt an acceptable result for the considered option. In order to do so, a graduated scale, divided into five zones is developed for each of the parameters volume flexibility, lead time and total cost. Furthermore, for each of these parameters there is a limit that, without exceptions, cannot be exceeded. If this level, however, is reached, then the measure of the parameter enter zone 1, which in turn implies immediate termination of the investigation. If the evaluated parameter adapts a degenerated, but still acceptable, value in compare to the current level, this corresponds to a result value in zone 2. Further, zone 3 is equivalent to the current level and a result value in zone 4 corresponds to an improvement of the evaluated parameter. Consequently, zone 5 indicates a significant enhancement in compare to the present parameter value. Finally, as all three parameters that are analyzed in this step of the make-or-buy decision model use different measurements, individual zone limits need to be constructed for each parameter. Furthermore, some of these limits require enhanced user dedication, as these are context specific and therefore differ from case to case. Thus, an individual and more detailed description of how to determine if an acceptable level is generated for the investigated setup, for each one of the three parameters, is given below.

Beginning with volume flexibility, the current level is represented by an interval, $x - y$, spanning from the lowest to the highest number of complete customer orders that SED is able to manage with the present capacity on a monthly basis. This level is illustrates as zone 3 in the graduated measurement scale for this parameter, seen in figure 20 to the right. Furthermore, if the investigated make-or-buy setup generates up to 20 % degeneration in comparison to the present setup’s value of volume flexibility, then this result in a volume flexibility value located in zone 2. This limit has been chosen as is it important that the supplier is able to respond to changes in demand. However, as this parameter is hard to estimate, it cannot be too strict, considering that this parameter is a knockout criterion. Furthermore, this degeneration can imply both a removal of the lower limit to a higher lowest value, or a decrease of the highest acceptable level. In more detail, if zone 2 is entered, the volume flexibility interval in zone 3 has been reduced with up to 20 %. If the volume flexibility interval decreases with more than 20 %, this result in an invalid parameter value in zone 1 and consequently the make-or-buy investigation can be terminated. Similar, if the parameter is improved and the current interval in zone 3 is expanded, a volume flexibility level in the zone 4 or 5 is achieved. To reach zone 4, an improvement of the volume flexibility value with up to 20 % is required. An even higher level of volume flexibility will result in a zone 5 value. The mathematical formula for the percentual change of the initial interval can be seen below as formula 2,
where $y_1 - x_1$ represent the current interval, and $y_2 - x_2$ the interval of the considered option.

Formula 2: \[
\text{percentual change in volume flexibility} = \left( \frac{y_2 - x_2}{y_1 - x_1} - 1 \right)
\]

In the case of investigating an outsourcing setup, a prerequisite when evaluate this volume flexibility intervals is that the supplier is able to offer the required capacity. Specifically, the supplier needs to be able to produce an amount of rig that is located within the current volume flexibility interval at SED, zone 3. A capacity that is adopted to an interval outside the boundaries of zone 3 is not acceptable, even if the supplier interval is as wide spanned as SED’s. Furthermore, another requirement that needs to be fulfilled in order for a new volume flexibility interval to be valid is that the escalation, or de-escalation, has to be implemented within three month. Additionally, this new level of volume flexibility needs to withstand six month, otherwise it cannot be classified as the new standard level. This reasoning was confirmed by the supervisor at SED. Finally, all values that have been presented are, at this stage of the development of the make-or-buy decision model, no more than test values. Therefore they will be re-evaluated and tested in order to be further adapted and improved.

Figure 22: Evaluation of lead time

Regarding the next evaluated parameter, lead time, this can also be divided into five zones, where the current lead time, measured in days, is represented by zone 3, as illustrated in figure 21 to the left. The red line symbolizes the limit of what increase in lead time that is acceptable and what level that is not. Similarly to the volume flexibility parameter, if the red line is transcended and zone 1 is entered, then an invalidly high lead time is generated and the make-or-buy investigation is consequently terminated. This limit is represented by the time it takes from ordering call off articles until the assembly of the rig is completed of the specific drill rig. The reason for this is that if this time is exceeded, then the customer lead time will be affected which is not an option. Zone 2, in turn, includes values of lead time that correspond to a degeneration of the parameter, compared to the current lead time, without exceeding the termination limit. Similarly, zone 4 is reached if the current lead time is reduced, but not enough to have an impact on the time it takes from ordering call off articles until the assembly of the rig is completed. Zone 5 corresponds to a lead time that reduce the time it takes from ordering call off articles until the assembly of the rig is completed, as this will have a positive impact on the end customer. In addition to this, these limits are a first draft and they may be changed when testing and evaluating the decision model.

Finally, it needs to be determined that the total cost of the considered option reach an acceptable level. Similarly to the previous parameters, the current level of the total cost is represented as zone 3, as can be seen in figure 22 to the right. This current cost has, however, a span of ± 5 % to cover up uncertainties. Furthermore, a non-acceptable level of total cost is generated if the current total cost increases with more than 5 %, illustrated as zone 1 and 2 in figure 22. This limit was chosen based on discussion with the supervisors at SED, who stated that nearly no cost increase is acceptable. Finally, zone 4 and 5 represent a decrease in the total cost with intervals of 5 – 10 % and more than 10 % respectively. That a 10 % decrease of the total cost is needed in order to enter zone 5 is
based on the view that this percentual decrease is a valuable improvement in line with the discussion with the supervisor. These limits, however, are only test values and it is possible that they will be revised in an updated version of the model. Furthermore, one drawback when using these limits is that the percental increase or decrease in cost is not related to the total costs of SED. Hence, the total value of the costs that are associated with producing the considered module is not put into relation to the total costs of SED. When revising the first draft of the decision model it will thus be evaluated if this limitation can be avoided.

If it is determined that the evaluated parameters individually adapt an acceptable level for the considered setup meaning that none of the parameters received a result in zone 1, the next step, illustrated as step 3c in figure 19 above, is initiated. This step includes an evaluation of whether the parameters volume flexibility, lead time and total cost reach an acceptable level collectively. The criterion that needs to be fulfilled in this step is that at least one of the parameters reaches a result in zone 4. If so, the two other parameters can receive a zone 2 or 3 level and it is still interesting to continue with the investigation, as the parameter that scored a zone 4 or 5 result may compensate for the others deterioration results. Consequently, at least one of the parameters needs to be improved in order for the investigation to be worth to continue to the next step. If it is determined that this criterion is satisfied, the user of the make-or-buy decision model should exceed to the next step.

Moreover, in order to obtain a result that is as objective as possible it is important that representatives from several of functions at SED participate when conducting the analysis. Otherwise there is a risk that relevant aspects are overlooked or given too low priority. With regard to this, it is preferable if all the functions are represented when conducting the analysis. In order to make a time efficient analysis, however, it is advisable that sub-tasks are performed by separate functions and thereafter presented and inspected by the remaining functions.

7.2.4 Step 4: Evaluation of risk
When step 3 is finalized, and if it is determined that the parameters volume flexibility, lead time and total cost all reach an acceptable level, the investigation continuous with execution of step 4. In this step, the risks associated to the make-or-buy decision are analyzed. In figure 23 below, a detailed description of this step in the model is illustrated.
Figure 23: Detail description of how to evaluate risk

First, illustrated as step 4a in figure 23 above, the consequence and likelihood of each of the respective risks need to be determined. In more detail, the likelihood and consequence of the respective risks will be measured on a scale from 1 – 5. On this scale, the likelihood is spanning form rare to almost certain and the consequence of the risk is ranging from insignificant to severe, according to figure 24 below. Furthermore, if the likelihood of the risks is hard to evaluate, fault tree analysis is one example of methods that can be used, see step 4b in figure 23 above. By usage of this approach and by decomposing the risk into root events and the estimation of the likelihood of these, an indication of the probability of the risk that is evaluated is generated. Additionally, the questions that are presented in in section 6.3.7 can act as a guide when the likelihood and consequence of a certain risk is determined. The end user will, thus, take the context into consideration, which will make this assessment more reliable. However, one drawback with the usage of this risk assessment method is that the user’s personality, worldviews, culture, psychosocial factors, personal experience and education may affect the assessment. Therefore, in order to enhance the objectivity when this method is practiced, several employees from different
departments should be involved in the risk assessment. In that way, more than one perspective into the risk is generated and the effect of personal factors will be reduced. Additionally, relevant empirical data or actual observations can be used, as well as usage of expert opinions, in order to aid the risk assessment and its accuracy.

Figure 24: Risk evaluation by estimating the consequence and likelihood

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Insignificant</td>
</tr>
<tr>
<td>(1) Rare</td>
<td>1</td>
</tr>
<tr>
<td>(2) Unlikely</td>
<td>2</td>
</tr>
<tr>
<td>(3) Possible</td>
<td>3</td>
</tr>
<tr>
<td>(4) Likely</td>
<td>4</td>
</tr>
<tr>
<td>(5) Almost certain</td>
<td>5</td>
</tr>
</tbody>
</table>

Once the likelihood and consequence of each of the respective risks has been assessed, the risk factor can be calculated by multiplying these numbers, illustrated as step 4c in figure 23 above. Next, step 4d in figure 23 above, a determination of whether the individual risk factors reach an acceptable level needs to be performed. Furthermore, if any of the risks are assessed with a risk factor that is equal to or higher than 20, the investigation will be terminated as there is a too high risk associated with the considered make-or-buy setup. In addition to this, the make-or-buy investigation may still be terminated even if none of the risks generates a risk factor of 20 or more. This occurs if the sum of all individual risk factors, namely the total risk factor, is determined as too high. Consequently, this is evaluated in step 4e, as clarified in figure 23 above. In order to set an upper limit for this total risk factor, formula 3 below should be used. This limit was established as at least the consequence or the likelihood need to be assessed as level four and the other at a level three. By using this limit, an average value higher than 12 of the individual risk factors is considered as non-valid.

**Formula 3:** \( \text{total risk factor} < \text{number of individual risks} \times 12 \)

Finally, in order to evaluate the considered make-or-buy setup it needs to be compared to the current setup, illustrated as step 4f in figure 23 above. Therefore, unless the make-or-buy investigation has been terminated as a consequence of too high risks associating to the considered setup, it is necessary to evaluate the risks connected to the current setup. Thus, the same method as described should be used to investigate the current risks that are associated to the make-or-buy decision. When doing this, some of the risks may not be applicable in the current setup and these risks will thus be given a risk factor of 0. Similarly, if some additional risks are relevant to consider when analyzing the current setup these should be added to the assessment. Once the risks that are associated to the current make-or-buy setup have been identified, they can be used as an additional validation of what risk level that is determined as acceptable. If comparison with the current risks still indicates that the risks of the considered setup are under the established limit, the make-or-buy investigation should continue with the following step in the model.

7.2.5 Step 5: Syntheses of all parameters

The final step in the make-or-buy decision model is to evaluate the remaining parameters in order to gain further input into the make-or-buy decision. Furthermore, if the previous steps have strongly indicated that the considered make-or-buy setup is advantageous, the outcome of the remaining parameters, evaluated in this step, will not impact the decision. Nevertheless, an evaluation of these parameters is still
preferable as it will provide information that is necessary to consider when implementing the decision. In addition, if the previous steps have not strongly indicated that the considered setup is favorable, an evaluation of the remaining parameters will contribute with necessary information in order to make a final decision. In figure 25 below, a detailed description of this last step of the make-or-buy decision model is illustrated.

**Figure 25: Detailed description of synthesis of the parameters**

![Diagram](image)

Moreover, the remaining parameters will be evaluated together with the previously investigated parameters in order to attain a final decision. This will be done by giving the respective parameters an individual weight and score, illustrated as step 5a in figure 25 above. As the parameters volume flexibility, lead time, total cost and risk are of higher importance these will, thus, receive a fixed weight of 10 on the scale 1 – 10. The remaining parameters, however, will be determined by the user, of the make-or-buy decision model, who is delegated a total weight of 10 to divide among these. This is illustrated in table 6 below, where the remaining parameters have received a fictive weight of \(x\). Thus, the remaining parameters will collectively be given importance equal one of the highly ranked parameters.

Furthermore, in order to be able to compare the respective parameters with each other it is necessary to measure them on the same scale. The scale 1 – 5 will thus be used as the parameters module characteristics, volume flexibility, lead time and cost already are estimated by using zones 1 – 5. In order to clarify, zone 1 correspond to a score of 1 and so forth. As the risk parameter, however, was assessed differently, the result from this step in the model needs to be converted to the scale

<table>
<thead>
<tr>
<th>Average individual risk factor</th>
<th>Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>(12 \leq x)</td>
<td>1</td>
</tr>
<tr>
<td>(11 \leq x &lt; 12)</td>
<td>2</td>
</tr>
<tr>
<td>(8 \leq x &lt; 11)</td>
<td>3</td>
</tr>
<tr>
<td>(4 \leq x &lt; 8)</td>
<td>4</td>
</tr>
<tr>
<td>(x &lt; 4)</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table 6: Conversion of the risk score**

75
In order to establish zones in the risk analysis, the average individual risk factor is calculated. If an average individual risk factor of 12 or more is obtained, this corresponds to zone 1. In the same way, the other zones are based on the average individual risk factor, according to table 6 above. These limits were chosen as they were established as suitable according to tests.

Similarly, it is necessary to evaluate the remaining parameters and give them a score on a scale from 1 – 5, respectively. In order to aid this process, the questions in section 6.3 can act as a support. Similar to the evaluation of prior parameters, however, it is worth to note that the questions only act as support and that the end-user needs to interpret the impact of the respective answers to the questions. Finally, once all the weights and scores for the respective parameters have been established, the next step is to calculate the weighted score by multiplying the weight with the score, illustrated as step 5b in figure 25 above. Subsequently, the sum of the weighted scores should be calculated and a determination of whether the total weighted score reach an acceptable level is executed, illustrated as step 5c in figure 25 above. If this sum is 170 or higher it indicates that the considered make-or-buy setup is favorable. If the sum is lower than 170, however, the current setup is preferable. This value is chosen as this value is attained if the parameters volume flexibility, lead time, cost analysis and risk receive a score of 4 respectively, regardless of what score the remaining parameters receive. In addition, this limit is chosen as test value and will be verified in the case study. Table 7 below can be used when conducting this analysis.

<table>
<thead>
<tr>
<th>Sub-parameters</th>
<th>Weight</th>
<th>Score</th>
<th>Weighted score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume flexibility</td>
<td>10</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Lead time</td>
<td>10</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Total cost</td>
<td>10</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td>10</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Time flexibility</td>
<td>$x_1$</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Improved R&amp;D operations</td>
<td>$x_2$</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Acquiring competitive knowledge</td>
<td>$x_3$</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Product flexibility</td>
<td>$x_4$</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Opportunity to share risk</td>
<td>$x_5$</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Long-term capacity</td>
<td>$x_6$</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td><strong>Sum:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Synthesis of all the parameters
8 In depth analysis

In this section, a more in depth analysis will be conducted in order to evaluate if the make-or-buy decision model can be improved in any way. A re-evaluation of the first draft of the decision model will be executed, followed by a discussion regarding areas of improvements. The analysis will be executed by gaining additional inputs from a calculative case study, interviews at both SED and external suppliers as well as a workshop at SED. The process will be supported by research question number five, which was presented in the problem specification section.

8.1 Introduction to research questions

Once the first draft of the decision model has been established, the next step is to review and improve this version. This will be done by executing a case study, where the decision model will be tested by following the instructions. Moreover, in order to gain further input into how the first draft of the decision model can be improved, interviews will be held with representatives from different functions at SED. Interviews will also be conducted with external suppliers so as to receive input from the suppliers’ perspective as well. Furthermore, a workshop with the intended end-users from concerned functions will be held at SED in order to receive input from the end-users. Based on this, the first draft of the make-or-buy decision model will be revised into a new and improved version. In order to give guidance in this process, the following question has been formulated:

RQS: Can the make-or-buy decision model be improved in any way, with regard to the context of SED?

8.2 Re-evaluation of the decision model

In order to find improvement areas in the make-or-buy decision model, the first draft is re-evaluated. In more detail, these improvements may regard the representation of the parameters in the model and whether the general structure is appropriate or not. Furthermore, it may be concluded that there are parameters that have been overlooked and hence need to be included in the updated version of the model. Another scenario is that modifications in the existing parameters are required. This could be regarding aspects such as an insufficient specified measurement method, additional perspectives of the parameter that are unintentionally overlooked or whether some aspect of the parameter can be eliminated. Moreover, set zone limits and the parameter priority is additionally aspects that may be areas of improvements when the final version of the make-or-buy decision model is developed. Finally, by testing the first draft of the model, inputs regarding usage of the model might be gained.

Furthermore, when re-evaluating the decision model additional input was gained regarding the respective parameters and the evaluation method. Nonetheless, the added information did not result in any changes in the parameters core competence, time flexibility, competitive knowledge, the opportunity to share risk and long-term capacity. The reason for this is that the information that was gained during the in-depth analysis supported the existing evaluation method and hence there was no need to modify these.

8.2.1 Modifications in existing parameters

When evaluating the first draft of the make-or-buy decision model, requirements of modifications in existing parameter have been identified. In specific, suggested changes in the parameters volume flexibility, lead time, cost, risk and improved R&D operations are discussed below.

Modifications in the volume flexibility parameter

Furthermore, when evaluating the parameter volume flexibility in the case study, the question regarding whether there are any other indications that can aid the estimation of this parameter was raised. When interviewing representatives from the strategic purchasing and production purchasing functions this question was thus discussed in order to obtain further input. According to these interviews, it is not only beneficial if SED is an important customer that stands for a considerable ratio of the supplier’s total turnover. In more detail, if SED stands for a major ratio of the supplier’s total turnover it may result in
lower volume flexibility, as the supplier cannot move around employees from other assembly operations in order to handle temporary variations in demand. If the supplier, however, is concentrated on production towards many other customers as well they have better prerequisites for being able to even out their production according to variations in SED’s demand. Another aspect that was identified during the interviews is that the size of the external supplier also is relevant to evaluate when assessing volume flexibility. The reason for this is that small suppliers generally lack resources to control their internal operations efficiently. If the supplier is too large, however, they might be less service-minded and thus neglect the wishes of SED. Hence, it is necessary to evaluate both the size of the external supplier and whether SED is an important customer or not. In addition to this, as the suppliers are further away from the actual demand in the supply chain than SED, they are generally less equipped for managing a higher level of volume flexibility, according to production purchasing.

Moreover, through interviews with representatives from the production function and by conducting the workshop at SED, additional input regarding volume flexibility was acquired. First, it is misleading to measure volume flexibility based upon the monthly output. A more suitable measurement approach is to base this evaluation on the takt time which is measured at SED and describe the average number of produced drill rigs every workday. By utilizing this parameter, regards has been taken to the fact that the months consist of different amount of workdays. Secondly, there is no requirement on high volume flexibility in a time period up to three months, as SED’s ambition is to have a stable production plan within this period. Moreover, any magnitude of volume changes which are applicable six months from now is presumed to be manageable. This implies that the time period which is of interest when investigating the volume flexibility parameter is three to six months from now. Hence, when calculating the current volume flexibility level, the average takt time should be based on historical data from the preceding twelve months. When this calculation is performed, only the rigs which include the considered module should be assessed. The current volume flexibility interval should thereafter be determined based on what percentual increase or decrease SED is able to handle. Furthermore, after conducting the workshop it has been verified that the zone limits of 20 % still are applicable.

**Modifications in the lead time parameter**

Through interviews with the production department, a deeper insight into how the parameter lead time affects the decision was gained. First of all, the ordering of call off articles do not affect the investigated lead time. The reason for this is that SED utilize a set freeze time, for when an order needs to be confirmed in order to initiate the administration and assembly of the order. Within this fixed time period, no changes in the customer order are thus allowed. This fixed freeze time will therefore not be changed, regardless of which call of articles that are ordered. As all call of articles are ordered within the freeze time, this implies that some of the suppliers may need to produce based on prognosis in order to satisfy the short demand on lead time. It is hence relevant to evaluate what degree of accuracy that the supplier requires on SED’s prognosis, as a more detailed prognosis is harder for SED to supply. In addition to this, another aspect that was highlighted during the interviews with the production department, if the supplier needs a detailed prognosis, this will result in a higher risk for SED. The reason for this is that if the prognosis is inaccurate it may be hard for the supplier to supply SED with the requested module or article in time, which may have a negative impact on the end customer. Also, if SED’s prognosis is misrepresentative, it may result in them being obliged to buy material that is not needed. Hence, the requirement of a more detailed prognosis results in a higher risk for SED.

One aspect that on the other hand can affect the lead time is the total assembly lead time, which was stressed during interviews with the production function. In the case of considering insourcing, it is hence relevant to investigate if the start of the pre assembly needs to be initiated earlier. This is illustrated in figure 26 below, where $S_1$ represent the current start of the pre assembly and $S_2$ represent the new start time after transferring the considered module to the internal production. Similarly, in the case of outsourcing, it is of interest to evaluate if the total assembly lead time can be reduced.
Figure 26: Illustration of how the lead time may be affected when considering insourcing

Furthermore, another aspect that also is relevant to investigate is the volume value that SED order based on prognosis, according to interviews with the production function. Based on the lead time, some articles may need to be ordered based on prognosis. That is, if the lead time is longer than the set freeze time. Moreover, it is desirable to reduce the number of articles that are ordered based on prognosis as they induce a risk to SED. The reason for this is that the uncertainty increase, as the customer demand may change and result in the storage of unwanted articles.

It is also worth to stress, that SED always is interested in reducing the lead time of the article and modules, according to interviews with the production function. The reason for this is that short lead times reduce the inventory stock value and makes it easier to handle last minute changes. Moreover, by reducing the lead times of the articles it might be possible to reduce the total lead time towards the customer, in the long run. However, as previously stated, it is particularly beneficial if the lead time can be reduced so that the number of articles that are ordered based on prognosis can be reduced.

**Modifications in the cost parameter**

When conducting the calculating case study and interviewing the production department, additional input regarding the material handling costs, administrative costs and the transportation costs was gained. All these sub-cost parameters are classified as overhead costs and are hence currently allocated to the final products as a percentual material overhead supplement, according to the production function. Thus, as SED currently use overhead costs in order to allocate the material handling, administrative and transportation costs these parameters can be represented as one parameter that can be estimated. However, it is worth stressing that this allocation of overhead costs does not fairly estimate how the overhead activities are affected by the make-or-buy decision. The reason for this is that the material overhead supplement is calculated based on the current setup and the changes in workload that the make-or-buy decision may generate are not included. The method used for allocating the overhead costs at SED thus result in an unfair cost allocation, as all products are given the same percentual supplement despite the fact that they are using the firms resources and activities to different extents. This disadvantage of using the overhead supplement became very clear when conducting the case study, as this method do not correctly mirror the changes that the make-or-buy decision invoke. In addition to this, when interviewing the production function it was emphasized that this supplement cost has not been updated for several years which further motivate that it should not be used. Hence, using this method is not an alternative.

Instead of using the overhead cost allocation that was described above, a more detailed estimation of how the administrative and material handling cost will change can be achieved by using the questions that were formulated in section 6.3.8. As the material handling costs are affected by the number of suppliers, and not only the number of handled articles, this should also be considered. In order to estimate the extent of these costs, it can hence be useful to analyze how the number of orders are affected by the make-or-buy decision and calculate the cost change with the help of the cost of an order, which is available at SED. This information was obtained through interviews with representatives from the production department.

When estimating how the changed make-or-buy setup affects the administrative costs, the effect on the
supplier base needs to be further analyzed. The reason for this is that the amount of actively used suppliers is affecting the administrative operations related to process planning, ordering articles and planning the production, according to interviews with the production purchasing function. In the case of transferring the assembly of a module to an external supplier, the amount of orders connected to this module is distinctly reduced. However, this does not necessarily imply a reduced administrative cost for managing the ordering operation. The reason for this is that the supplier used for acquiring the articles of the module may be used for acquiring other articles as well and hence orders still need to be placed despite the changed make-or-buy setup regarding the considered module. In the worst case scenario, all current suppliers need to be maintained and the same amount of orders still need to be placed, with addition of the module supplier as the only change. Consequently, this needs to be further investigated prior to the make-or-buy decision is made. In reverse, if the module is transferred from an external supplier to the internal production, the supplier base may be in need of an update and it might be necessary to introduce several new sub-tier suppliers. However, some existing suppliers might be able to deliver articles that are needed when manufacturing the module, why further investigation regarding how the supplier base is affected by the make-or-buy decision is suggested. Nevertheless, through interviews with the production function it was highlighted that most of the orders only include one article, and therefore the number of orders gives a good indication of how the administrative costs are affected by the decision.

The changes in transportation costs, however, are rather hard to estimate as emphasized through interviews with representatives from the production function. As SED transports articles from all over the world, and given the possibilities to utilize the shared infrastructure support within the Atlas Copco Group, it is possible that a greater extent of consolidation can be achieved by buying a module from a supplier that is located abroad in comparison to a supplier at the domestic market. Therefore, it is not necessarily the distance to the supplier that determines the magnitude of the transportation cost. Furthermore, as the inbound logistics cost at the supplier affect the price of the articles or module, it is even harder to estimate the change in transportation cost caused by the decision. The reason for this is that the transportation cost depends on the localization of the sub-tier suppliers, as illustrated in figure 27 to the right. In the figure, there is a much longer distance between SED and supplier 1 (S1) in comparison to the distance between SED and supplier 2 (S2) and consequently the transportation cost should be lower in a setup which implies transactions with supplier 2. However, when taking the sub-tier suppliers’ location into consideration and the cost of the suppliers’ inbound logistics, this may not be the case, as illustrated in figure 27. With regard to this it is hard to deduce how the transportation costs will change in response to the make-or-buy decision, in accordance with interviews with representatives from the production department. Additionally, these interviews indicated that the transportation cost is not of crucial importance in this type of decision making, as this is a relatively small cost in this context.

Moreover, to ensure that there is enough available production area, or in-house capacity, is another aspect that has been highlighted as important to consider prior to the make-or-buy decision, in line with interviews with the production department. In more detail, when investigating whether to transfer an activity from an external supplier to the internal production, the cost of acquiring additional production area need to be estimated. This cost aspect is preferably included in the manufacturing cost analysis. On the contrary, if an outsourcing setup is considered, an investigation of what estimated value the released production space has is suggested. Furthermore, according to interviews with the production department, prior outsourcing decision has been executed as a result of a growing business and hence a delimitation in
In depth analysis

production area. Consequently, the advantages of released production space can be realized as significant, in particular if it can be utilized by operations aiding a growing business. Increased safety in the production operations is another advantage of additional production space. Indirectly, this can be counted as a reduced manufacturing cost in the long term perspective, as the sick leave rate is expected to decrease. Finally, the released production area can be used as storage area, which may result in a lowering of material handling costs. The reason for this is that articles stored in an external warehouse can be moved closer to the production, with a more convenient material handling approach as a result. Additionally, if external warehouse space is reduced, this may result in a decreased facility rent.

Moreover, through interviews with strategic- and production purchasing, a deeper insight was given into the research and development function. In contrast to prior assumptions, SED do not pay their suppliers to participate in the research and development activities. Rather it is in the suppliers’ own interest to be part of these activities as they can influence SED to make constructions that can simplify their work. In addition to this, the suppliers are often service-minded and interested in cooperating with their ideas in order to attain a successful relationship with SED. Furthermore, in the instances where SED buy the construction of an external supplier, it is part of the price of the product. Hence, it is not relevant to investigate the cost of involving the supplier in these activities as no such specific cost exists.

In the evaluation of the transaction cost it is assumed that this cost will increase if it is decided to transfer an activity to an external supplier. The reason for this is that the introduction of an additional strategic supplier relation will result in additional negotiations and increase the amount of work related to the monitoring of supplier agreements and the business contracts. However, when the model was tested and according to interviews, with production technique and research and development, this may not be entirely true and before any assumption can be made, a further analysis is suggested. Regarding the opposite scenario, where an activity is transferred to the internal production, this will result in a shift from one strategically important module supplier into a setup where purchasing from a larger number of sub-tier supplier. The transaction cost of maintaining the relationship with the strategic supplier will hence be eliminated. However, it will be replaced by a cost associated to the transactions with the sub-tier supplier. Depending on how many entirely new suppliers that need to be introduced when the considered module is insourced, and all material acquiring is done in-house, this transaction cost vary in magnitude. If sub-tier suppliers that already are part of the supplier base can be used, the transaction cost most certainly will be reduced in comparison to the initial make-or-buy setup. The reason for this is that these types of suppliers need less attention and negotiation and hence these relations are monitored to a lower cost. On the contrary, if few or none of the existing suppliers can be utilized, new suppliers need to be introduced, with a high transaction cost as a result.

Furthermore, another aspect that affects the magnitude of the transaction cost is the cost of the travels to the supplier. Face-to-face meetings are a significant part of the work of creating and maintaining the business relationship with the suppliers, according to interviews with representatives from both suppliers and the strategic purchasing department at SED, as this need to be regularly executed. This cost hence depend on the location of the eventual supplier and, in particular if a foreign supplier is used, this cost should not be overlooked.

Finally, it is also worth to stress that when implementing a make-or-buy decision there will initially be higher costs than estimated. The reason for this is that it is costly to make changes and it is reasonable to assume that it will take some time before the processes functions as normal. For example it will take some time to implement the decision, including finding and approving possible new suppliers and perhaps terminating the relationship with existing suppliers. In addition to this, it will also take some time before the manufacturing process operates smoothly which will result in increased costs initially. In more detail, there needs to be an initial learning phase for the employees that are going to take part of the transferred operations. Apart from this, there is also an additional non-recurring cost of transferring part of the
production in-house, in the case of insourcing, or to an external supplier, in the case of outsourcing. Thus, it is relevant to assume that the decision will result in high initial costs, when implementing the decision. This insight was attained through both supplier visits and interviews with representatives from the production.

**Modifications in the risk parameter**

In order to facilitate the evaluation of the operational risk at an external supplier, the audit process and supplier evaluation procedure that are presently included in the strategic purchasing operations can act as support, according to representatives from the concerned department. The assessment includes a determination of the supplier’s quality, safety and reliability performance, how the supplier work within these areas and what efforts that are made in order to make improvements. Moreover, the supplier’s problem solving methods and crisis management are analyzed. In more detail, during these procedures it is determined whether the supplier practices a fire fighting approach rather than utilizing proactive problem solving and quality ensuring processes. By using this audit questionnaire, that are used by the strategic purchasing department, or the results from the supplier assessment, the estimation of the operational risk in the supplier setup can thus be facilitated.

The sub-parameter regarding the risk of becoming too dependent of a supplier address the scenario where SED run the risk of being looked up in a business relationship with a supplier in an outsourcing setup. This risk is, in particular, relevant to consider in cases where aspects such as strict requirements of delivery according to plan, well-functioning communication and the presence of both willingness and competence of adaption of new technology and technical changes exists. If the supplier is not able to meet these requirements, this will most likely have a devastating effect on SED’s operations, as this dependency risk is highly relevant to consider. However, the opposite scenario where the supplier encounters the risk of becoming too dependent on SED as a customer is a risk aspect that has not been given any attention in the risk analysis in the first draft of the make-or-buy decision model. According to interviews with representatives from the strategic purchasing department, this risk needs to be taken into consideration as well. Today, there is a corporate policy that states that SED should not be standing for more than 30 % of a supplier’s total turnover. If this limit is transcended, SED as a customer undertake a too large responsibility and the supplier’s survival may in fact rely on the business relationship with SED. In turn, this morally responsibility result in an inability to leave the business relationship, even if there was not an initial risk of becoming too dependent on the supplier from SED’s perspective. Despite the fact that there already exists a policy regarding this scenario and that this aspect is included in the processes regarding supplier assessment, this situation occasionally occurs at SED. Consequently, this risk of becoming a too significant customer to a supplier in an outsourcing setup should be taken into consideration when the risk analysis is conducted.

Another aspect of risk that is not included in the first draft of the make-or-buy decision model concern the sub-parameter loss of control, which was highlighted by the research and development department. In an outsourcing setup where the supplier is involved in the technical design operations, it is necessary to still keep control over what changes in the constructional drawings that are made. The main reason for this is that the aftermarket requires updated material in order to endow customers at the field with right spare parts. Consequently, it is of high importance that a distinct responsibility division is made in the outsourcing supplier relationship and that SED provides processes and creates a forum intended for this information sharing in order to reduce this risk. Furthermore, if the supplier is given free hands to make own decisions in too large extent, there is a risk of duplicate mistakes that already have been made internally. As described by a representative from the research and development department, the supplier does not have the historical documentation and the experience that exist internally. This in turn reduces the understanding of the present circumstances and implies that there is a risk that the supplier makes changes to the worse if insufficient communication appears. For example, sub-tier suppliers may be replaced as a consequence of a decision made by the supplier and as a result of this, all work with the production.
previous sub-tier suppliers will be lost. Hence, this consequence of the risk of losing control is appropriate to take into consideration as well, before the make-or-buy decision is made.

Furthermore, through interviews with the production function an additional risk was identified, namely supply disturbance. This risk refers to the situations where the production at SED is disturbed as a consequence of delayed delivery from the supplier. In more detail, when buying a module from an external supplier, SED becomes more sensitive to this risk as deliveries on time are crucial. When the module is produced in-house, however, this consequence of this risk is not of the same magnitude as it might be able to continue with the assembly anyhow. Moreover, in the case of internal production, SED has a safety stock on frequent material why a supply disturbance may not result in any disturbance on the production. In addition, if there is an error with the supplied module it often requires a greater effort to correct the error if the module is not produced internally. The reason for this is that if the module is produced internally, additional articles might be available in stock as an internal safety measure while this opportunity does not exist when buying from an external supplier. Furthermore, as the competence regarding the specific module is available in-house, when the module is assembled in-house, these errors can be less time consuming to fix. In addition, if an article needs to be exchanges it often takes longer time to receive the new articles, in the case of buying the module from an external supplier. The likelihood of this risk is connected to how detailed prognosis that is required by the supplier, as discussed in the lead time-discussion.

**Modifications in the parameter improved R&D operations**

Another aspect, that was highlighted during interviews with representatives with the R&D function, is that this department is affected in another way than perceived based on the academic findings. In order to clarify, the theoretical study emphasized that when collaborating with an external supplier there was an ability to improve the internal operations as more knowledge, or additional resources, could be gained. However, according to interviews with R&D and production technique at SED, the research and development function is rather affected negatively by collaborating with an external supplier, as the operation becomes more time-consuming. In more detail, it is harder to search and correct errors if the production is located at an external supplier. The process of implementing new constructions and quickly receiving input from the assembly is also facilitated if the production is located internally, as emphasized through interviews with the research and development function.

Hence, when transferring a module to an external supplier the work of the research and development function is most likely negatively affected. In addition to this, the possibility to acquire more knowledge through collaborating with the supplier, as assumed when constructing the first draft of the decision model, is rather unlikely according to the research and development function at SED. The reason for this is that, unless the supplier is responsible for the construction, they have little input into how the module can be improved and even if they do have inputs they lack the knowledge of the overall product and synergy effects that can be achieved throughout the firm. Hence, the work of the research and development function will most likely be best performed if the considered module is assembled in-house. Therefore, with this new insight into how this function is affected by the make-or-buy decision, this parameter should be given more importance in the make-or-buy decision model.

Nevertheless, in the case of collaborating with an external supplier, it can be beneficial to involve the supplier in the research and development operations as it might be possible to gain input that can lower the production cost at the supplier. This input was received through interviews with the production function.

### 8.2.2 Additional parameters

The core competence evaluation in the initial part of the first draft of the make-or-buy decision model gives a valuable insight into whether the considered module is suitable to transfer to an external supplier, in the case of investigating an outsourcing setup. However, it is not only the core competence aspect that
is relevant to consider in order to determine how suitable a changed make-or-buy setup is. Through interviews with representatives from both the research and development department and production technique, it has become clear that the characteristics of the considered module also are highly interesting to investigate. Firstly, it is appropriate that the considered module has distinct and logical interfaces with the surrounded components. In that way, the division of responsibility areas between the included parties is more easily conducted. More specifically, this will proactively counteract duplication of work that may occur if there is any ambiguity regarding area of responsibility of the considered module. This aspect is further supported by Mikkola (2003) who suggest that modular outsourcing is preferable if the considered sub-component are distinctly defined and consists of well specified and standardized interfaces. Most preferable for an outsourcing setup are highly standardized serial produced components, according to the research and development function. This is supported by Vining and Globerman (1999) who argue that a standardized product are well suited for outsourcing as it offers potential for both lowering the production cost and the transaction cost. Furthermore, a standardized product implies that the contract is easily specified and, additionally, that there are many potential suppliers which make inefficient or opportunistic behaving suppliers easily exchanged, according to Vining and Globerman (1999).

Another aspect that is of interest to consider before the make-or-buy decision is made is how often changes and technical updates is performed at the considered module, the extent of these and furthermore if these changes affect any other part of the final product, as stressed through interviews with the R&D and production technique. Similarly, the opposite scenario regarding how the considered module in general is affected by changes in other parts of the drill rig is of interest to investigate as well. The reason for this is that a part that is highly affected by other components and changes in these is less suitable for outsourcing, as this will complicate the R&D work and most likely increase the requirement of communication and information sharing which in turn would result in higher indirect costs. Moreover, outsourcing of such a component would increase the time consumption of several development projects with a less efficient development process as a result, according to interviews with representatives from the research and development and the production technique. Consequently, the characteristics of the considered module can give an indication of whether it is appropriate to produce this at an external supplier or not and, in the case of outsourcing, how much extra work that may occur.

Similarly, it is also relevant to investigate how suitable the considered module is to transfer to the internal production. First of all, an aspect that needs to be considered is whether the considered module can be easily integrated into the current production flow, with regard to the production rate, according to the production function at SED. As SED strive to have a production rate that is as even as possible, it would thus be problematic if the considered module cannot be adapted to the current rate. Moreover, when transferring a module to the internal production it is also crucial that the considered module can be integrated into the remaining operations at SED. For example, it is vital that updated structures and drawings are available. The reason for this is that it is difficult for SED to produce the module in a quality ensured way unless this information is available, as stated during interviews with the R&D operation.

Moreover, when visiting the suppliers C, D and F the question was raised regarding whether the suppliers where content with their current situation or wanted to become more or less involved. While supplier F was content with the current setup supplier C and D expressed a wish to become more involved in the research and development of the considered module. Supplier C also expressed a desire to become involved in the manufacturing of certain articles that SED currently buy from other suppliers. Through these discussions, awareness was hence raised regarding the possible benefits of investigating what the supplier can and is interested in offering. For example, it might be possible to develop safer and more cost and time-efficient modules by engaging the supplier more in the research and development operations. Similarly, it is possible that other advantages such as supplier base reduction can be achieved by involving the module supplier in additional operations. With this in mind, it is useful to have a dialogue with the...
supplier in order to investigate what services they are willing and able to supply. Based on this, an internal analysis can thereafter be conducted in order to establish which of these that are of interest at SED, given the current circumstances.

As previously discussed, another aspect that was emphasized by the research and development function and production technique is that it is important that SED remain in charge of the construction, even if this function is outsourced to an external supplier. The reason for this is that SED possess a broader perspective of how to “produce the Atlas way” and what requirements that need to be fulfilled or are desirable in line with the directives of the Atlas Copco Group. If the supplier is in charge of the construction, and makes changes without SED’s consent, there is thus a risk that synergy effects are lost and that the Atlas Copco trademark is weakened. It is, nevertheless, preferable to involve the supplier when making a change in the construction, in order to assure that they are able to make the desired adaptations. Similar to this, it is also important to have clearly defined responsibility areas when collaborating with the supplier, as stressed by strategic purchasing and the research and development function. This aspect was also highlighted during one of the supplier visits, where there was a disagreement on who was responsible of the module and its respective components. Hence, in order to reduce the cost associated with errors and delimitations in product quality it is essential to have a mutual agreement on responsibility areas.

Furthermore, when testing the first draft of the model by conducting the case-study an increased awareness was raised regarding how important it is to have a good process and prerequisites for smooth communication and information sharing. This includes communication and information sharing both between different functions internally at SED as well as with the supplier base. According to interviews with production technique and the research and development function, this process is negatively affected by transferring part of an activity to an external supplier. The reason for this is that it is much easier to quickly implement changes and resolve conflicts if there are few parties involved and if all the parties are located at the same location. In addition to this, if the supplier is located abroad, there is a language barrier that might complicate the communication and information sharing further. Hence, the work of production technique and the research and development function is in particular facilitated if the assembly is performed in-house.

As previously mentioned, another issue that is connected to the supplier, is that if the supplier has the possibility to choose their own sub-tier suppliers it might complicate SED’s relationship with these. That is, if SED have a good relationship with several of suppliers that have previously been responsible for supplying articles to a specific module this relationship might be damaged if the external suppliers wish to change supplier. Hence, the work that SED have put into building a fruitful relationship with the supplier and ensuring that they fulfill SED’s all requirements might be lost. Therefore, an extra parameter that was highlighted during the supplier visits is that it might be worth evaluating whether the supplier should have the responsibility to choose sub-tier suppliers or not.

An additional aspect regarding the make-or-buy decision that was apparent during the supplier visits is that there are many different setups for outsourcing which will result in different cost effects. For example, the supplier can be responsible for buying and storing all the articles they needed for the assembly and thus be in charge of purchasing and storing of the articles. One another possible setup is that the supplier only is responsible for assembly and that SED remain in charge of purchasing and storing of articles that are sent to the supplier for manufacturing. With this in mind, the chosen outsourcing setup with the supplier will naturally affect which advantages or delimitations that can be achieved. Therefore, the considered setup should preferably be discussed and agreed upon internally, before request of quotations to the considered supplier is sent out. This includes clearly defining what the potential supplier respective SED should be responsible for. This was concluded during the workshop, where the representative from strategic purchasing stressed that it is necessary to internally discuss the
configuration of the make-or-buy setup prior to involving the supplier. Similarly, it is also important that representatives from SED internally agree on the objectives of the considered make-or-buy setup, in order to ensure a common view.

Furthermore, when conducting the workshop it became clear that the possibility to easily bring home an outsourced operation also is an aspect that is of interest to consider. As the market demand vary, it can be desirable to transfer assemble of an outsourced module back to the internal production when the demand is low, according to representatives from the production department. Similarly, it can also be relevant to bring the assembly of an outsourced module in to the internal production due to other reasons as well. For example, one reason is if the re-evaluation indicates that the outsourcing setup is not the most appropriate approach after a period of time. Furthermore, if the supplier does not live up to what has been stated in the supplier agreement is another reason to change back to the initial make-or-buy setup. Hence, when outsourcing it is important to create prerequisites that enable an easy transfer of the assembly of the considered module back to the in-house production, according to the production function.

Additionally, as previously discussed, the communication and information sharing process is most likely negatively affected by transferring part of an activity to an external supplier. Hence, it is important to establish efficient communication processes and create good prerequisites for information sharing. Through dialogue with strategic purchasing during the workshop, it was concluded that this preferably should be determined prior to involving the supplier in these discussions. The reason for this is that it is easier to negotiate with the supplier, and write contracts that cover up all relevant aspects, if these matters have been discussed and agreed upon internally. It is also important that these processes are continuously evaluated and improved, once the collaboration has been established, in order to be able to quickly resolve issues and share information.

8.2.3 Modifications in set limits and parameter priority
When conducting the case study, a reflection that was made is that no concern is taken to how small or big the estimated cost changes are, relative to the total costs of the firm. In more detail, the limit of what cost change that is accepted or not is a percentual limit of the current cost of the make-or-buy setup. Hence, if the current cost is very low a much smaller increase in cost is accepted than if the current cost is higher. Nonetheless, it might be relevant to not only investigate what percentual increase or decrease that is accomplished but to also taken into consideration how big the total cost for the decision is relative to other costs at the firm. Thus, if the total cost for the current make-or-buy setup is very high, a lower percentual increase might be tolerated. If, however, the current cost for the make-or-buy setup is very low, a higher percentual increase might be accepted. Therefore, the limit of what percentual increase or decrease that represents the different zones should be determined by the end-user, from case to case. These limits should be set prior to the performance of the total cost analysis in order to avoid a bias result.

Furthermore, by conducting the workshop it became clear that the parameters volume flexibility, lead time and total cost is not is not of equal importance. In more detail, as SED constantly work with lowering the production cost of the drill rigs and as this parameter is directly connected to the profit it is of highest significance. Similarly, the volume flexibility is of higher importance than lead time, as it can be devastating if the supplier fails to adapt to the changes in demand. More specifically, a failure in this parameter might affect the output, and hence prevent the end customer from receiving the order on desired time as production may need to postpone the order. Lead time, however, is also of great importance, but compared to total cost and volume flexibility, this criterion is less strict according to discussions at the workshop.

Moreover, an additional aspect that was highlighted during the workshop was that if any of the parameters module characteristics, lead time, volume flexibility, total cost analysis and risk is
degenerated, and thus end up in zone 2, a clear motivation is needed if the investigation should be continued. The reason for this is that these parameters are of high importance and hence it is not desirable to degenerate any of these. In some circumstances, however, it can be motivated to proceed with the investigated alternative anyway, why zone 2 should not result in the termination of the make or buy assessment.

8.2.4 Additions regarding usage of the model

By testing the first draft of the make-or-buy decision model through execution of the calculative case study, further input regarding ease of usage of the model was gained. In order to improve this aspect of the model, an addition regarding who the most suitable user is, in the different steps of the model, should be communicated in some way. By suggesting department and position of the user in each step of the model, the time consumption of using the model can be reduced. In addition, some steps is appropriately performed by representatives from more than one function, as inputs from different perspectives will give extra value to the process, why this should be specified in the model as well.

Furthermore, when visiting the suppliers an increased awareness was raised regarding the importance of re-evaluating the make-or-buy decision. The reason for this is that the context and circumstances that motivated a decision may not still be applicable. With regard to this, it is therefore necessary to re-evaluate the make-or-buy decision regularly in order to assess which make-or-buy setup that is most advantageous given the current conditions. This aspect is also supported by Kumar et al (2010) who stress that, given the dynamic external environment, it is vital to re-evaluate the decision once made.
9 Final version of the make-or-buy decision model

In this chapter, the final version of the make-or-buy decision model will be developed. Based on the result generated from the in depth analysis in the previous section, modifications of the first draft of the model will be made. First, the general structure of the updated model will be presented. Finally, a detailed description of each of the modifications that are made will be given.

9.1 General structure

In figure 28 below, the updated version of the make-or-buy decision model is illustrated. As can be seen in the figure, an additional step where the characteristic of the considered module is evaluated is added. This evaluation is preferably performed directly after the core competence analysis, and is therefore illustrated as step 2 in figure 28 below, as these two investigations both consider the specific attributes of the module, or activity, which is under investigation. Further, if the characteristics of the module are not suitable for the investigated make-or-buy setup, it is not of interest to further evaluate this alternative and the make-or-buy decision process can consequently be terminated regardless of the outcomes of the other parameters. As a suitable module characteristic is a prerequisite in order to go on with the make-or-buy investigation, this parameter can be considered as a knockout criterion, similar to the core competence parameter. This is an additional reason why the characteristics of the module are evaluated early in the make-or-buy decision model.

Moreover, another update from the first draft of the decision model is that the decision should be regularly re-evaluated, as illustrated in the figure 28 below. In more specific, as the outcome of the make-or-buy investigation is highly dependent on the specific context of the firm and the present market situation, it is not certain that the same result is generated at a later stage, as the internal and external condition change. In order to make sure that the most suitable make-or-buy approach is practiced, the setup consequently should be re-assessed on a regular basis.

Finally, an additional box of aspects that are relevant to keep in mind when facing a make-or-buy decision has been added. These parameters are not illustrated as steps in the make-or-buy decision model as they are not decisive for the outcome of the make-or-buy investigation. However, these aspects may affect some of the other parameters, why they need to be taken into account. For example, the configuration of the supplier relation, regarding which part that is responsible for purchasing and storing articles, has an impact on the total cost analysis. Furthermore, the prerequisite regarding communication and information sharing with the supplier in an outsourcing setup determine the effort and time, and hence the cost, it will take to manage the supplier relation. These additions will be discussed in more detail in the following sections together with additional modifications in the existing steps.
Figure 28: General structure of the final version of the make-or-buy decision model

Step 1: Core competence?
   - Yes
   - No

Step 2: Suitable characteristics of the module?
   - Yes
   - No

Step 3: Determine the configuration of the make-or-buy setup.

Step 4: Send out request of quotations to potential suppliers.

Step 5: Acceptable level of volume flexibility, lead time and total cost?
   - Yes
   - No

Step 6: Acceptable risk factor?
   - Yes
   - No

Step 7: Evaluate the sub-parameters; time flexibility, R&D, competitive knowledge, product flexibility, possibility to share risk and long term capacity.
   - Have the previous steps given an ambiguous answer?
     - Yes
     - No
   - Favourable level of the of all parameters in synthesis?
     - Yes
     - No

Proceed with the considered alternative.
9.2 Detailed description of modifications

In this section, a detailed description regarding the changes in the existing steps and additional improvements of the make-or-buy decision model will be presented. Firstly, the alterations that regard the existing parameters and steps will be comprehensively described. Next, a detailed description will be presented regarding how the additional steps should be evaluated. Thereafter, the modifications that have been made to the set limits will be presented as a final step.

9.2.1 Step 1: Evaluation of core competence

The first step of the make-or-buy decision model is to make an evaluation of whether the considered module is a core competence or not. This step has not been modified and should thus be evaluated in accordance with the description presented in the first draft of the make-or-buy decision model. To aid the evaluation, questions are presented in appendix 2 and 3. This procedure is illustrated in figure 29 below.

Figure 29: Detailed description of how to evaluate core competence

9.2.2 Step 2: Evaluation of module characteristics

When the first step of the final version of the make-or-buy decision model is finalized, and it is determined that the considered module not is classified as a core competence, the next step can be initiated. This second step consists of an evaluation of whether the characteristics of the module are suitable for the considered setup or not. A detailed description of the procedure of this step is visible in figure 30 below.
As this step includes a new parameter that was not included in the first draft of the make-or-buy decision model, it is necessary to determine how this parameter should be measured. If an outsourcing setup is under investigation, it is essential to conclude what level of standardization of the considered module that applies. The more standardized the more suitable is the module for an outsourcing setup. The reason for this is that a standardized component is easier to effectively produce as possibilities to get access of the eventual economies of scale and scope in the supplier’s operations exists. Furthermore, a standardized module is easier to manage and monitor, less efforts need to be made in order to get a well-functioning supplier collaboration in such cases. Secondly, it is relevant to investigate if the considered module has distinct and logical interfaces with the surrounding components. This will indicate how easily the responsibility allocation between SED and the considered supplier can be performed. In addition to this, it is interesting to evaluate how often changes and technical updates are performed at the considered module, the extent of these and further how these changes affect the remaining components of the drill rig. Finally, the opposite scenario, regarding if changes in other part of the drill rig will affect the considered module needs to be analyzed. In the case of investigating a transfer of a module from an external supplier to the internal production, the possibilities to integrate the module into the internal production flow, with regards to the current production rate, need to be analyzed. Similarly, it is also relevant to assess how easily the considered module can be integrated into the remaining internal operations. In more detail, when transferring a module to the internal production it is for example important that updated module drawings and structures are available. To summarize, the below stated questions can act as support when evaluating the characteristics of the module in step 2a, as illustrated in figure 30 above. The questions are also presented in appendix 4, in order to aid the investigation.

- In the case of considering transferring an activity to an external supplier, how suitable is the considered module for an outsourcing setup?
  - How standardized is the considered module?
  - Does the module have distinct and logical interfaces with the surrounded components?
  - How often are changes and technical updates performed at the considered module?
    - What is the extent of these? Do these changes affect any other part of the final product?
  - How is the considered module in general affected by changes in other parts of the drill rig?

Figure 30: Detailed description of how to evaluate module characteristics
rig?

- In the case of considering transferring an activity to the internal production, how suitable is the considered module to produce in-house?
  - Can the considered module easily be integrated into the in-house production flow, with regard to the current production rate?
  - How easily can the considered module be integrated into the remaining internal operations, with regard to aspects such as updated structures and drawings?

When the evaluation of the characteristics of the module is performed, the next step, illustrated as step 2b in figure 30 above, can be initiated. In this step, a determination of whether an acceptable module characteristic is present or not should be conducted. As the characteristics of the module can be more or less suitable for a changed make-or-buy setup, this parameter is preferably measured on a graduated scale divided into five zones, similarly to those used in step 3 in the first draft of the make-or-buy decision model. Here, zone 3 represents a scenario where the module, which is under investigation, is as suitable for the considered make-or-buy setup as for the current situation. Zone 2 indicates that the considered module is less suitable for the investigated make-or-buy scenario in comparison to the present approach. In contrary, if the newly considered setup is more appropriate for the considered module regarding its characteristics, than a result in zone 4 is generated. Furthermore, if the characteristics of the module are much more suitable for the considered approach in comparison with the current setup, then a zone 5 result is attained. Finally, if the characteristics of the considered module are highly maladjusted to the investigated make-or-buy approach, then a zone 1 result is generated. This in turn indicates a non-acceptable scenario and the make-or-buy assessment can be terminated, as illustrated in figure 31 above.

9.2.3 Step 3: Configuration of the make-or-buy setup

When conducting the make-or-buy decision analysis it is important to keep in mind that the outsourcing setup can be configured in many different ways. Hence, it is necessary to have an initial idea of how the setup should be configured when evaluating the decision. Thus it is important that representatives from different functions at SED, together agree upon how the relationship with the supplier should be configured. It is also important to have clearly defined responsibility areas with the selected supplier, in accordance with the result from the workshop. This includes aspects such as whether the supplier should be responsible for purchase of materials, storage of articles and construction. It is also important that representatives from SED internally agree on the objectives of the collaboration with the external supplier, in order to ensure that they have a common view. Moreover, when implementing an outsourcing setup it is also important to establish processes and prerequisites that enable efficient information sharing and communication with the supplier. This is extremely important in order to avoid deficiencies in quality and other communication issues. In addition to this, it can also be favorable to have a dialogue with the potential suppliers in order to receive input on what services they can and are willing to supply. Additionally, it is important to create prerequisites that enable an easy change back to the initial make-or-buy setup as discussed during the workshop.

In order to aid this investigation, the questions below have been formulated. These questions can also be found in appendix 5.

- How should the supplier relationship be configured?
- What are the objectives of the collaboration?
- What should the supplier respective SED be responsible for? (In terms of for example construction, storage, supplier selection, purchase, prognosis, transports and equipment)
- What is expected of the supplier respective SED, in terms of communication?

- What prerequisites are required in order to easily change back to the initial make-or-buy setup?

Similarly, in the case of considering insourcing, it is also relevant to establish the internal objectives, prerequisites, responsibility areas and how the internal production should be configured.

9.2.4 Step 4: Sending out request of quotation
The next step is to send out request of quotations to potential suppliers. When this step is conducted, it is important that the information gained from the discussions regarding the supplier relationship configuration is taken into consideration.

9.2.5 Step 5: Evaluation of volume flexibility, lead time and total cost
If the previous steps have not resulted in the termination of the make-or-buy analysis the next step is to evaluate the parameters volume flexibility, lead time and total cost. This evaluation should be performed by first evaluating the respective parameters individually and thereafter making a collective assessment, as illustrated in figure 32 below. How these evaluations should be performed was described when presenting the first draft of the make-or-buy decision model. Moreover, the individual evaluation of the respective parameters has been updated with some additional aspects that are important to include in the make-or-buy analysis. These changes will thus be discussed in more detail below.

**Figure 32: Detailed description of how to evaluate volume flexibility, lead time and total cost**

- **Step 5a:** Evaluate volume flexibility.
- **Step 5b:** Evaluate lead time.
- **Step 5c:** Evaluate total cost.

**Volume flexibility**
As previously discussed, if SED stands for a considerable ratio of the suppliers production it may not only result in higher volume flexibility. In more detail, if SED stands for a significant ratio of the suppliers total
production it can result in higher volume flexibility as the supplier may prioritize SED’s requests. Nevertheless, if the supplier’s production is mainly concentrated on manufacturing SED’s products it may result in lower volume flexibility as the supplier have small possibilities of evening out their production in accordance to variations in demand. This aspect is thus important to keep in mind when evaluating the question regarding whether SED stands for a considerable ratio of the suppliers production or not. Similarly, it also worth to keep in mind that SED’s suppliers generally have less good prerequisites for handling variations in demand due to them being further away from the actual customer demand in the supply chain.

An additional aspect that was not included in the first draft of the make-or-buy decision model is that the size of the supplier also can be relevant to consider when evaluating the parameter volume flexibility. The reason for this is that small suppliers generally lack resources to control their internal operations efficiently. If the supplier is too large, however, they might be less service-minded and thus neglect the wishes of SED. With regard to this, the supplier should neither be too small nor too large. In order to take this aspect into consideration, the following question is added to the evaluation of volume flexibility in the case of considering outsourcing:

- How large is the potential supplier, in comparison to SED?

An updated version of all the questions that are relevant to consider when evaluating volume flexibility is available in appendix 6. As discussed in the in depth analysis, when measuring the volume flexibility parameter, the takt time should be used. Additionally, it is the volume flexibility level three to six months from now that is of interest to consider. Furthermore, once the parameter volume flexibility has been evaluated with the help of the questions it should be assessed on a scale from 1 – 5 in accordance with the description presented in the first draft of the make-or-buy decision model. Based on this evaluation it will also be determined whether the level of attained volume flexibility is acceptable or if the analysis should be terminated.

**Lead time**

Continuing with lead time, as has been established in the in depth analysis, it is relevant to investigate whether the considered option will have an impact on the assembly lead time. Furthermore, it is also of interest to investigate how the number of articles, or rather the volume value, that is ordered based on prognosis is affected by the decision. Finally, in the case of considering outsourcing, it is also relevant to establish what level of prognosis that is required by the considered supplier. With regard to this, the following questions have been formulated to aid the investigation:

In the case of considering an outsourcing setup, how will the lead time parameter be affected?

- Is it possible to decrease the total assembly lead time by implementing an outsourcing setup?
- Is it possible to decrease the number of articles ordered based on prognosis by implementing an outsourcing setup?
- What level of prognosis is required by the supplier?

In the case of considering the transfer of a module to the internal production, how will the lead time parameter be affected?

- Is it necessary to increase the total assembly lead time by transferring the considered module to the internal production?
Is it necessary to increase the number of articles ordered based on prognosis by transferring the considered module to the internal production?

An updated version of all the questions that are relevant to consider when evaluating the parameter lead time is available in appendix 7. Moreover, once this parameter has been evaluated it should be assessed on a scale from 1 – 5 in accordance with the description presented in the first draft of the make-or-buy decision model. Based on this evaluation it will also be determined whether the attained lead time is acceptable or not. As illustrated in figure 33 above, the limits have also been updated according to the discussions in the in depth analysis.

**Total cost**

As previously concluded SED utilize a material overhead cost supplement in order to make sure that the administration, transportation and material handling costs are covered. However, this percentual supplement gives a poor description of how these costs are affected by the make-or-buy decision and will therefore not be used. Furthermore, as was concluded in the in depth analysis, the transportation costs are hard to deduce and as these costs have a relatively small impact on the decision they will not be investigated. The administration and material handling costs, however, are important to include in the total cost analysis. In order to assess these costs, it is relevant to investigate how the number of orders and the supplier base is affected by the decision. As previously discussed, it is also relevant to investigate if any storage space can be reduced, in the case of outsourcing, or if it is necessary to increase the storage space in the case of insourcing. It is also relevant to investigate how the required equipment, number of handled articles and number of employees are affected by the make-or-buy decision. All of these aspects should thus be considered in order to make an estimation of how the make-or-buy decision affects the administrative and material handling costs. The questions below have thus been added to aid the assessment.

- In the case of considering transferring an activity to an external supplier, how are the administration and material handling costs affected?
  - Is it possible to reduce the number of storage locations?
  - Is it possible to reduce equipment used in the material handling operations?
  - Is it possible to reduce the number of material handling employees?
  - Is it possible to decrease the number of handled articles?
  - How are the supplier base and the ordering procedure affected by the changed make-or-buy setup?
  - How is the total number of orders affected?

- In the case of considering transferring an activity to the internal production, how are the administration and material handling cost affected?
  - Is it necessary to increase the storage space?
  - Is it necessary to increase number of handled articles?
  - Is it necessary to reduce equipment used in the material handling operations?
  - Is it necessary to increase the number of material handling employees?
  - How are the supplier base and the ordering procedure affected by the changed make-or-buy setup?
  - How is the total number of orders affected?

Furthermore, continuing with the manufacturing costs it is necessary to also include the cost for production space. Hence, in the case of considering outsourcing, it is relevant to investigate if any production area can be released. Similarly, in the case of considering insourcing, the cost for the required additional production area should be estimated. Thus, the questions below have been added to the original questions that were presented in the first draft of the make-or-buy decision model.

In the case of considering transferring an activity to an external supplier:
Is it possible to release any production area?

In the case of considering transferring an activity to the internal production:

What is the estimated cost for acquisition additional production area?

Moreover, as previously discussed, when estimating the transaction cost it is relevant to investigate how the supplier base is affected by the make-or-buy decision. This includes an assessment of which strategic and sub-tier suppliers that have been added or removed from the supplier base as these types of suppliers need varying degrees of attention and negotiation. In addition, in the case of in-sourcing, if few or none of the existing suppliers can be utilized, new suppliers need to be introduced, with a high transaction cost as a result. Furthermore, an additional aspect that affects the transaction cost is where the current or potential supplier is located as this will affect the extent of the travel costs. The following question should thus be considered when evaluating the make-or-buy decision.

What is the estimated cost for travels to the supplier?

Furthermore, as previously concluded, apart from the above cost parameters the cost for implementing a make-or-buy setup will most certainly be higher than estimated. The reason for this is that it is costly and takes time to implement large logistic changes. Apart from this, it will also take some time before the manufacturing and administrative functions work according to plan and are up to speed. With regard to this, the sub-cost parameter implementation cost will be added to the cost analysis. As this cost is not an annual cost it will not be included in the cost analysis between the current costs and the cost of the considered option. It is, nonetheless, still relevant to evaluate this cost parameter in order to assess what additional costs an implementation of the considered setup will generate. Moreover, the questions below can act as support when making this analysis.

- How large is the estimated cost for implementing the decision?
  - What is the estimated cost for implementing changes in the production and warehouse area?
  - What is the estimated cost for running the production while the administrative and manufacturing process is not up to speed yet, as a consequence of an initial learning and implementation phase?

Figur 34: Evaluation of total cost

An updated version of all of the questions that have been formulated to aid the evaluation of the respective cost parameters is available in appendix 8. Moreover, when the cost parameters have been evaluated they should be assessed on a scale from 1 – 5, as described in the first draft of the make-or-buy decision model. However, as discussed in the in depth analysis, it is relevant to take the relative cost change into consideration. With regard to this, the production cost (PC) of the rig will be used in this assessment. In more detail, if the change in total cost result in an increase in 0,5 % or more in the PC the investigation should be terminated, which is illustrated as zone 1 in figure 34 below. Similarly, if the considered make-or-buy setup should result in a reduction of the PC by 0,5 % or more, it corresponds to zone 5. As illustrated in figure 34 below, the current level of total cost corresponds to zone 3 and zone 4 and 2 represent a small decrease or increase in cost. These limits were agreed upon during the workshop.

Moreover, even if the relative impact of the cost analysis is of high importance it is also interesting to evaluate the percentual cost change of the considered module. The reason for this is that the assessment of the relative cost change allows a high percentual cost increase of low valued modules. As this is not
desirable, it is thus relevant to maintain the original evaluation of the percentual cost change. With regard to this, this criterion will also be used in order to evaluate zone 1 and 5. During the workshop this percentual change was discussed and the limit was thus updated to 25% in accordance with the discussions. This implies that zone 1 and 5, respectively, have two criteria. This is illustrated in figure 34 to the left.

Furthermore, depending on what level that the total cost analysis receive on this scale the make-or-buy decision analysis will be terminated or continue to the next step. If the individual analysis of the cost parameter indicates that the evaluation should be continued, the next step is to evaluate the parameters volume flexibility, lead time and cost collectively.

As previously discussed, the parameters total cost, lead time and volume flexibility are of dissimilar importance which should be reflected in the collective assessment, illustrated as 5c in figure 32, of these parameters. Thus, as the total cost parameter is of highest importance, an improvement in at least in one of the other parameters do not suffice to continue with the investigation. Rather an improvement in both lead time and volume flexibility is required in order to continue with the investigation, given that the total cost is degenerated. If either volume flexibility or lead time are degenerated, however, it suffice with an improvement in at least one of the other parameters.

9.2.6 Step 6: Evaluation of risk

When step 5 is conducted and it is determined that an acceptable level of the parameters volume flexibility, lead time and total cost is obtained, the sixth step of the final version of the make-or-buy decision model can be initiated. Here, the risk analysis is performed as previously described in the first draft of the model, see figure 35 below to once again get the detailed description of the procedure.
However, there are some modifications and additions that were identified in the in-depth analysis that need to be included in this updated version of the decision model. To start with, the supplier evaluation process which is currently used by the strategic purchasing department, with associated audit questionnaire, can preferably be used as guidance in order to facilitate the evaluation of the operational risk. These questions will enhance the understanding regarding the supplier’s production operations, what knowledge related to these that exist and the quality insuring efforts that are made. In turn, this will hence give an indication of how likely an unintentional breakdown in the vendor’s operations is to occur, as these breakdowns or complications can be an effect of limited knowledge at the supplier.

Secondly, the risk of becoming too dependent on the supplier further on should include the aspect that the opposite scenario can occur as well. In more detail, there is a risk that SED becomes a too significant customer to the supplier, standing for a too great share of the supplier’s total turnover. This in turn, this leaves SED with a too large responsibility regarding the supplier’s survival and this may result in an
inability to leave the business relationship. This is the reason why this aspect needs to be considered when evaluating the consequence and likelihood of the risk parameter regarding dependency. The following sub-question aims to facilitate the evaluation of this addition:

➢ Is there any reason to fear that the supplier will become dependent on SED as a customer and hence make it morally wrong to leave the business relationship?

As discussed in the in depth analysis, another aspect of risk that has been overlooked and hence need to be included in the risk analysis in this final version of the decision model is an addition regarding the risk parameter loss of control. In more detail, it is necessary to still keep control over what changes in the constructional drawings that are made in a setup where the considered module are produced by an external supplier. The consequence of this risk scenario includes an increased difficulty for the service function to provide the aftermarket with right spare part with a decreased customer satisfaction as a result. Furthermore, if the supplier is entrusted too much responsibility, there is a risk of duplicate mistakes that already have been made internally, as the supplier does not have the historical documentation and the experience that exist internally. As a result, these consequences of the risk of losing control are appropriate to keep in mind when the outcome of this risk parameter is estimated.

Finally, as was concluded in the in depth analysis, it is also relevant to assess the risk of supply disturbances. When evaluating this risk it needs to be considered which impact a possible supply disturbance would have on SED’s internal production. That is, will it be possible to continue assembling the rig or not, given that the whole module, part of the module or just a single article on the module needs to be exchanged. Moreover, it is also relevant to analyze historical data, in order to get an idea of how likely it is that supply disturbances occur. Finally, should a supply disturbance occur it is important that it is solved as soon as possible. With regard to this, the supplier’s prerequisites for quickly fixing a disturbance should be investigated.

What are the likelihood and consequence of the risk supply disturbances, in the considered make-or-buy setup?

➢ What effect would a supply deficiency caused by the considered supplier have on SED’s internal production?
➢ Based on historical data, it is likely that supply disturbances will occur?
➢ What prerequisites for quickly fixing the supply deficiency does the considered supplier have?

An updated version of questions to facilitate the risk evaluation can be seen in appendix 9.

9.2.7 Step 7: Syntheses of all parameters

The next step in the make-or-buy decision model is to make a final assessment of all the considered parameters, as illustrated in figure 36 below.
Moreover, in accordance with the discussions in the in-depth analysis, the work of verifying and ensuring the product quality as well as product update is also affected by the make-or-buy decision. Therefore, the parameter regarding the R&D operation has been modified. To clarify, product update here refers to the continuous work of improvements concerning existing rig models. This differs from the parameter product flexibility, as this parameter rather concerns the ability to produce entirely new rig models which in turn will lead to an update of the firm’s total product range. Moreover, in order to estimate the impact on this newly added parameter, it can be useful to evaluate whether there are any differences in quality when producing the module in-house versus production at an external supplier. Moreover, it is also relevant to investigate whether any differences in how time consuming the error searching and correcting operations are expected as a result of the considered make-or-buy setup. When considering the transfer of a module to an external supplier, it can also be of interest to evaluate whether the potential supplier takes proactive actions to ensure a high quality or not as this might give an indication of whether the supplier will provide a high quality or not. Similarly, if any other firm within the Atlas Corporation has cooperated with the potential supplier, or any other reviews are available, it can be worth to compile statistics on how well the supplier has performed historically. Finally, it is also relevant to investigate how the communication and work effort, of implementing product changes or improving quality aspects, will be affected by the make-or-buy decision. The following questions have thus been formulated to aid the evaluation:

- In the case of considering transferring an activity to an external supplier, how will the R&D operations be affected?
  - According to statistics, is there any difference in quality related costs when producing the
module in-house versus production at an external supplier?

- Is there any difference in how time consuming the error searching and correcting operations are, when producing the module in-house versus production at an external supplier?
- What proactive actions are taken by the supplier in order to reduce quality delimitations?
- How well has the supplier performed historically, in the instances where such statistic is available?
- How will the communication and work effort be affected, when implementing product and quality related changes, by the make-or-buy decision?

- In the case of considering transferring an activity to the internal production, how will the R&D operations be affected?

  - According to statistics, is there any difference in quality related costs when producing the module in-house versus production at an external supplier?
  - Is there any difference in how time consuming the error searching and correcting operations are, when producing the module in-house versus production at an external supplier?
  - How will the communication and work effort be affected, when implementing product and quality related changes, by the make-or-buy decision?

In table 8 below, all the parameters that should be considered are summarized. The remaining parameters were initially given a total weight of 10 scores that the end-user should delegate according to how important the specific parameters are, with regard the context of the make-or-buy decision. As the parameter quality insurance and product update has been added however, and as this parameter is greatly affected by the make-or-buy decision, the remaining parameters should be given more importance in the final assessment. This is strengthened by the fact that, in the in depth analysis, several of these remaining parameters were shown to be more decisive in the decision process, than illustrated in the first draft of the model.

Moreover, as previously discussed the parameters total cost, volume flexibility and lead time should not be given the same weight. With regard to this, the weights of these criteria will be updated to better mirror these circumstances. Hence, the total cost will be given a weight of 15 instead of 10 in the final synthesis. Similarly, the volume flexibility will be given a weight of 12 instead of 10. Lead time and the parameters, module characteristics and risk, however, will remain a weight of 10 in the final synthesis. This is illustrated in table 8 below.

Additionally, in the case of considering the transfer of an activity to the internal production, the parameters competitive knowledge and the possibility to share risk is not applicable. With regard to this, it is necessary to distinguish between in- respective outsourcing when delegating weights to the remaining parameters and the limit for what score that is in favor of the considered option.

In the case of considering outsourcing, the end-user will therefore be given 30 scores that should be delegated as weights to the remaining parameters and the limit will be updated to 261. The reason why a total weight of 30 was chosen is that the remaining parameters are of less importance than the parameters module characteristics, volume flexibility, lead time, total cost and risk which all received weights of 10. Hence, it is appropriate to assign the remaining parameters an average weight of five, which corresponds to the value 30 as there are six remaining parameters. As argued before, if a score of three corresponds to neither an improvement nor a dis-improvement a total score over 261 is needed in order for the considered option to be in favor. However, if the total score is lower than this, then the current setup is more advantageous.

Similarly, in the case of considering the transfer of a module to the internal production, the end-user will
be given a total score of 20 to delegate to the remaining parameters. The reason for this is that in this case, there are two less parameters to take into consideration as the parameters competitive knowledge and the possibility to share risk is not applicable. With regard to this, the limit of what total score that needs to be achieved in order to favor the considered option is 231 in the case of insourcing. If the total score is lower than this, however, the current make-or-buy setup is more beneficial. Furthermore, questions that have been formulated in order to aid the assessment of the remaining parameters is available in appendix 10.

Moreover, when determining these new limits, consideration has been taken to the investigation of the parameters in step 1 – 5. As previously reasoned, if these parameters clearly indicate that the considered setup is favorable, it should result in the implementation of this setup. Nonetheless, as argued in the in depth analysis, the remaining parameters should receive higher importance. With regard to this, the limits were chosen so that a higher average score than four was needed on the first five parameters in order for the investigated make-or-buy setup to be favorable.

<table>
<thead>
<tr>
<th>Sub-parameters</th>
<th>Weight</th>
<th>Score</th>
<th>Weighted score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module characteristics</td>
<td>10</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Volume flexibility</td>
<td>12</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Lead time</td>
<td>10</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Total cost</td>
<td>15</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td>10</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Time flexibility</td>
<td>x₁</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Impact on R&amp;D operations</td>
<td>x₂</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Acquiring competitive knowledge</td>
<td>x₃</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Product flexibility</td>
<td>x₄</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Opportunity to share risk</td>
<td>x₅</td>
<td>1-5</td>
<td></td>
</tr>
<tr>
<td>Long-term capacity</td>
<td>x₆</td>
<td>1-5</td>
<td></td>
</tr>
</tbody>
</table>

**Sum:**

Table 8: Synthesis of all the parameters

Furthermore, it is also worth stressing that even if a total score that is over the limit is received, this does not necessarily mean that the considered option should be implemented. As previously discussed, the limit has been put so that they correspond to a score of three, on all the investigated parameters. Therefore, a total score of slightly over the established limits do not correspond to a clear yes. Rather they indicate that a deeper investigation and discussions need to be conducted, if the considered option should be proceeded with. Hence, the higher score that is received, a stronger indication is given. As has been previously discussed, when implementing a major logistic change like this, it will require a lot of planning, effort and it can be assumed that the total cost is higher than estimated. Therefore, it is necessary to put in some extra effort to really think trough and evaluate the implications before a firm decision is taken.
10 Conclusions

In the following section the authors’ reflections of the developed model will be presented after which a discussion regarding whether the model is generalizable or not will be held. Lastly, suggestions of further studies will end this master thesis.

10.1 Final result

The general structure of the final version of the make-or-buy decision model is presented in figure 37 below.

Figure 37: Final make-or-buy decision model
10.2 Reflections

When constructing the make-or-buy decision model, the aim has been to develop a model that makes a holistic analysis of what is the best strategy for the firm as a whole. Hence the views of representatives from several of departments have been taken into consideration, in order to gain a broad perspective of how the different functions are affected by the make-or-buy decision. This has resulted in a decision model that takes a broad spectrum of parameters into consideration in order to cover all essential aspects of the decision. One advantage with the decision model is thus that it takes both quantitative and more qualitative aspects into consideration and makes a holistic analysis of these. Naturally, however, it is possible to take even further parameters into account but in order to create a comprehensive model the focus has been on making an in-depth analysis on the most significant aspects of the decision.

Moreover, in order to avoid unnecessary effort for the end-user, the model has been constructed so that the most critical parameters are reviewed first. If evaluation of these parameters indicate that the set limit will not be attained the investigation should thus be terminated. The end-user can thus start evaluating the most critical parameters in order to determine if it is useful to continue with the rest of the investigation which is advantageous. An additional benefit of the developed make-or-buy decision model is that it is well adapted to the context of SED. This has been assured by gathering context specific information from interviews, the workshop, supplier visits and the case study. In addition to this, SED’s production strategy has been taken into consideration when selecting parameters in order to develop a decision model that is in line with the overall business strategy.

Furthermore, one limitation with the make-or-buy decision model is that the cost analysis can be improved in order to better mirror the changes that the make-or-buy decision will result in. As SED currently lack an efficient method for accurately dividing the overhead costs, the suggested cost analysis in the make-or-buy decision model can be improved. An additional drawback with the developed make-or-buy decision model is that it is hard to make an objective evaluation of the more qualitative aspects. Hence, even if the aim was to develop a decision model that result in an objective judgment of what make-or-buy setup that is most advantageous for the firm as a whole, it is still inevitable to take the end-users subjective opinions into consideration. In order to minimize this problem, it is important that the analysis is made by representatives from several of functions, as has been previously stressed. When conducting the make-or-buy decision analysis, it is therefore advised to start a project with representatives from the different functions that are affected by the make-or-buy setup. The project leader should thereafter appoint which function that is responsible for investigating each step or sub-step, together with a deadline for this. Even if sub-analysis are made by a specific function, however, it is important that the result of this analysis is presented and inspected by the remaining functions. Additionally, in order to help the end-users make an objective evaluation of the qualitative aspects, supportive questions have been formulated in order to notify the reader of issues that are relevant to consider when evaluating the specific parameter.

Furthermore, the make-or-buy decision model requires an active participation by the end-user with the implication that the analysis is rather time consuming. In order to make a context and situation specific evaluation, however, it is necessary that representatives from several of functions contribute by making calculations and assessments. Given that the aim is to make a thorough analysis of which make-or-buy setup that is most advantageous, it is thus unavoidable that work and time is required by the end-user. In addition, it is worth to emphasize that it is close to an impossibility to make an exact estimation of what costs or implications the considered make-or-buy setup will generate. Rather, the make-or-buy decision model aims to make a well-informed estimation that is as close to the real outcome as possible.

Moreover, when constructing the make-or-buy decision model, it has been challenging to clearly define and establish how the respective parameters and sub-parameters should be represented and measured. The reason for this is that the make-or-buy decision has an impact on many different aspects that are all
connected to each other. In addition to this, several of the parameters can also include different aspects depending on how they are defined. In order to avoid the same aspect from being representative and taken into consideration twice, effort has thus been placed at making clear distinctions between the existing parameters.

10.3 Generalization
The make-or-buy decision model has been developed with regard to the specific context of SED, which has resulted in a model that is adapted to SED’s current situation. Nevertheless, it is likely that the model can be used by other Atlas Copco companies as well, as they have the same corporate strategy and similar characteristics as SED. In addition, it is also possible that other firms, which act on a market with similar demand as SED, also can utilize the decision model. Moreover, the parameters that are included in the decision model make a good foundation for making any make-or-buy decision analysis. Should the model be used by another firm it might, however, be necessary to revise the included parameters and add or remove some of them in order to make a more context specific analysis. Similarly, it is likely that the priority of the parameters need to be revised, in order to better mirror which aspects that are most significant with regard to the specific circumstances.

Furthermore, when developing the make-or-buy decision model, the higher purchasing levels have been prioritized. To be more specific, the higher purchasing levels regard the acquisition of modules with a high degree of assembly, or even complete rigs. Nonetheless, the decision model can also be used on smaller assembly components, as the identified parameters are relevant to take into consideration when making this analysis as well.

10.4 Suggestions for further studies
As previously discussed, a limitation with the make-or-buy decision model is that the cost evaluation is hard to accurately estimate. Hence, a suggestion for further studies is to make a thorough investigation on how the overhead costs can be divided in order to better mirror reality and hence the understanding of how these overhead costs will be affected by the make-or-buy decision. One idea could be to investigate whether it would be more advantageous to use activity based cost calculations at SED, as this method uses resources, activities and cost-drivers in order to divide the overhead costs with the aim of making a more accurate allocation.
Reference list

Written references


References


Reference list


**Electronic references**


**Verbal references**

**Production department – SED**

Kajsa Asklöf Axin [continuous discussions]

Maria Brink [continuous discussions]

Mats Carlberg [2015-01-27] [2015-04-28]

Anders E Carlsson [2015-01-28]

Matilda Steen [2015-01-28] [2015-05-12]

Andreas Molin [2015-03-04]

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Åsa Eliasson [2015-01-28]

Anders Samuelsson [2015-01-29]

Erik Steen [2015-04-28]

**Research and development department – SED**

Carl Linden [2015-01-29]
Johan Haglund [2015-05-05]
Mats Berger [2015-05-07]

**Supplier C**
Marcus Helmersson. CEO. [2015-04-24]

**Supplier D**
Leo Sattar. Team Leader Purchasing. [2015-04-30]
Marco Siekmann. Supplier Quality assurance. [2015-04-30]
Paulo Pacheco. Team Leader production. [2015-04-30]

**Supplier F**
Fredrik Järnberg. Production Manager. [2015-04-21]

**Participants at the workshop [2015-06-03]**
Maria Brink. Production.
Matilda Steen. Production.
Mats Carlberg. Production.
Anders Samuelsson. Strategic purchasing.
Appendix 1: Risk Assessment Techniques:

1. Brainstorming
2. Structured or semi-structured interviews
3. Delphi Analysis
4. Checklists
5. Preliminary hazard analysis (PHA)
6. Hazard and operability study (HAZOP)
7. Hazard analysis and critical control points (HACCP)
8. Toxicity assessment
9. Structured “what-if” technique (SWIFT)
10. Scenario analysis
11. Business impact analysis (BIA)
12. Root cause analysis (RCA)
13. Failure modes and effects analysis (FMEA)
14. Fault tree analysis (FTA)
15. Event tree analysis (ETA)
16. Cause-consequence analysis
17. Cause-and-effect analysis
18. Layers of protection analysis (LOPA)
19. Decision tree analysis
20. Human reliability assessment (HRA)
21. Bow tie analysis
22. Reliability-centered maintenance
23. Sneak analysis (SA)
24. Markov Analysis
25. Monte Carlo simulation
26. Bayesian statistics and Bayes nets
27. FN curves
28. Risk indices
29. Consequence=probability matrix
30. Cost-benefit analysis (CBA)
31. Multicriteria decision analysis (MCDA)

---

### Appendix 2: Questions to facilitate the core competence evaluation

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 1a: Evaluation of core competence</th>
</tr>
</thead>
</table>
| **1.** Can the competence or activity, which is under consideration, be classified as a cross functional knowledge set or skill? | ➢ Do representatives from several departments and functions cooperate in order to execute the activity?  
➢ Is the activity or competence hard to imitate?  
➢ Is the activity or competence hard to replace by a substitute? |
| **2.** Is the competence or activity a flexible platform, that in the long term perspective is capable of adoption or evolution? | ➢ Is the market demand of the considered activity regularly reassessed in order to always be able to offer what the customers value over time?  
➢ Is the considered activity or competences directly adapted according to this market demand?  
➢ Are there a foundation and prerequisites that enable SED to make these adaptions easily? |
| **3.** How many competences or activities are considered to be core competences at SED? | |
| **4.** Is the considered activity a unique source of leverage in the value chain? | ➢ Is SED the only supplier of the considered activity? |
| **5.** Can the competence or activity be considered as an important aspect for the customer in the long run? | |
| **6.** Is the competence or activity an area where the company can dominate and which make the firm able to stay ahead of its competitors? | |
| **7.** Is the competence or activity embedded in the organization’s system? | ➢ Is the considered competence or activity expected to outlive the current staff members? |
Appendix 3: Questions to facilitate remaining core competence evaluations

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 1b: Evaluation of close core competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Can the considered activity be categorized as a close core activity?</td>
</tr>
<tr>
<td></td>
<td>➢ Are there tight couplings between the considered activity and any defined core competence?</td>
</tr>
<tr>
<td></td>
<td>➢ Is any defined core competence dependent on the activity, which is under investigation?</td>
</tr>
<tr>
<td></td>
<td>➢ Is any defined core competence expected to be negatively affected by outsourcing of the investigated activity?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 1c: Evaluation of core competence according to stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>What is seen as the most industry important competences and capabilities by the firm’s stakeholders?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 1d: Evaluation of value adding activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>If the considered activity is removed from the internal production, will enough value still be generated in-house, in order to gain profit?</td>
</tr>
<tr>
<td></td>
<td>➢ Does the activity, which is under investigation, correspond to a considerable ratio of the total value of the end product?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 1a: Evaluation of focus on core activities when insourcing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>In the case of transferring an activity from an external supplier to the internal production, is it possible to still have full focus on the core activities?</td>
</tr>
<tr>
<td></td>
<td>➢ Will the managers still be able to devote their attention and time on the core competences?</td>
</tr>
</tbody>
</table>
## Appendix 4: Questions to facilitate the module characteristics evaluation

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 2a: Evaluation of module characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> In the case of considering transferring an activity to an external supplier, how suitable is the considered module for an outsourcing setup?</td>
<td>▶️ How standardized is the considered module?</td>
</tr>
<tr>
<td></td>
<td>▶️ Does the module have distinct and logical interfaces with the surrounded components?</td>
</tr>
<tr>
<td></td>
<td>▶️ How often are changes and technical updates performed at the considered module?</td>
</tr>
<tr>
<td></td>
<td>What is the extent of these? Do these changes affect any other part of the final product?</td>
</tr>
<tr>
<td></td>
<td>▶️ How is the considered module in general affected by changes in other parts of the drill rig?</td>
</tr>
<tr>
<td><strong>2.</strong> In the case of considering transferring an activity to the internal production, how suitable is the considered module to produce in-house?</td>
<td>▶️ Can the considered module easily be integrated in the in-house production flow, with regard to the current production rate?</td>
</tr>
<tr>
<td></td>
<td>▶️ How easily can the considered module be integrated into the remaining internal operations, with regard to aspects such as updated structures and drawings?</td>
</tr>
</tbody>
</table>
**Appendix 5: Questions to facilitate the setup configuration evaluation**

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 3: Evaluation of the configuration of the make-or-buy setup</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>How should the supplier relationship be configured?</td>
</tr>
<tr>
<td></td>
<td>- What are the objectives of the collaboration?</td>
</tr>
<tr>
<td></td>
<td>- What should the supplier respective SED be responsible for?</td>
</tr>
<tr>
<td></td>
<td>(In terms of for example construction, storage, supplier selection, purchase, prognosis, transports and equipment)</td>
</tr>
<tr>
<td></td>
<td>- What is expected of the supplier respective SED, in terms of communication?</td>
</tr>
<tr>
<td>2.</td>
<td>What prerequisites are required in order to easily change back to the initial make-or-buy setup?</td>
</tr>
</tbody>
</table>
## Appendix 6: Questions to facilitate the volume flexibility evaluation

### Question Step 5a: Evaluation of volume flexibility

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 5a: Evaluation of volume flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In the case of outsourcing, what interval of incoming customer orders is SED able to handle every month?</td>
<td></td>
</tr>
<tr>
<td>➢ How many employees are capable of producing the module at SED and hence are able to execute several production operations? How many of these are capable of performing other tasks in the internal production?</td>
<td></td>
</tr>
<tr>
<td>➢ What possibilities of hiring external and temporary workforce exist?</td>
<td></td>
</tr>
<tr>
<td>2. In the case of outsourcing, what expected interval of incoming orders is the supplier able to handle every month?</td>
<td></td>
</tr>
<tr>
<td>➢ Do the considered suppliers focus their business on production of the considered module, and thus are characterized by economies of scale and scope?</td>
<td></td>
</tr>
<tr>
<td>➢ Is SED an important customer for the supplier, standing for a considerable ratio of the supplier’s total turnover?</td>
<td></td>
</tr>
<tr>
<td>➢ How standardized is the considered module?</td>
<td></td>
</tr>
<tr>
<td>➢ How many employees are expected to be capable of producing SED’s module at the supplier and hence are able to execute several production operations? How many of these are capable of performing other tasks at the supplier’s production?</td>
<td></td>
</tr>
<tr>
<td>➢ How large is the potential supplier, in comparison to SED?</td>
<td></td>
</tr>
<tr>
<td>3. In the case of considering the transfer of an activity to the internal production, what interval of incoming orders is the supplier able to handle every month?</td>
<td></td>
</tr>
<tr>
<td>➢ How many employees are capable of producing SED’s module at the supplier and hence are able to execute several production operations? How many of these are capable of performing other tasks at the supplier’s production?</td>
<td></td>
</tr>
<tr>
<td>4. In the case of considering the transfer of an activity to the internal production, what expected interval of incoming customer orders is SED able to handle every month?</td>
<td></td>
</tr>
<tr>
<td>➢ How many employees are expected to be capable of producing the module at SED and hence are able to execute several production operations? How many of these are capable of performing other tasks in the internal production?</td>
<td></td>
</tr>
<tr>
<td>➢ What possibilities of hiring external and temporary workforce exist?</td>
<td></td>
</tr>
<tr>
<td>5. What demand on volume flexibility is required?</td>
<td></td>
</tr>
<tr>
<td>➢ How has the customer demand changed and varied, historically?</td>
<td></td>
</tr>
<tr>
<td>➢ According to forecasts, what is the expected demand in the next 12 months?</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 7: Questions to facilitate the lead time evaluation

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 5a: Evaluation of lead time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> In the case of considering an outsourcing setup, how will the lead time parameter be affected?</td>
<td></td>
</tr>
<tr>
<td>➢ Is it possible to decrease the total assembly lead time by implementing an outsourcing setup?</td>
<td></td>
</tr>
<tr>
<td>➢ Is it possible to decrease the number of articles ordered based on prognosis by implementing an outsourcing setup?</td>
<td></td>
</tr>
<tr>
<td>➢ What level of prognosis is required by the supplier?</td>
<td></td>
</tr>
<tr>
<td><strong>2.</strong> In the case of considering the transfer of a module to the internal production, how will the lead time parameter be affected?</td>
<td></td>
</tr>
<tr>
<td>➢ Is it necessary to increase the total assembly lead time by transferring the considered module to the internal production?</td>
<td></td>
</tr>
<tr>
<td>➢ Is it necessary to increase the number of articles ordered based on prognosis by transferring the considered module to the internal production?</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 8: Questions to facilitate the total cost evaluation

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 5a: Evaluation of total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inventory carrying cost</strong></td>
<td></td>
</tr>
<tr>
<td>1. In the case of considering transferring an activity to an external supplier, how will the inventory carrying costs be affected?</td>
<td></td>
</tr>
<tr>
<td>- What is the current inventory carrying cost for the considered module and its respective articles?</td>
<td></td>
</tr>
<tr>
<td>- How high are the inventory carrying costs estimated to be when buying the module from an external supplier?</td>
<td></td>
</tr>
<tr>
<td>- How will the processed value of the complete rig be affected?</td>
<td></td>
</tr>
<tr>
<td>2. In the case of considering transferring an activity to the internal production, how will the inventory carrying costs be affected?</td>
<td></td>
</tr>
<tr>
<td>- What are the current inventory carrying costs when buying the considered module from an external supplier?</td>
<td></td>
</tr>
<tr>
<td>- What are the inventory carrying costs estimated to be if the considered module is assembled in-house instead?</td>
<td></td>
</tr>
<tr>
<td>- How will the processed value of the complete rig be affected?</td>
<td></td>
</tr>
<tr>
<td>3. What is the inventory carrying rate?</td>
<td></td>
</tr>
<tr>
<td><strong>Material handling and administrative costs</strong></td>
<td></td>
</tr>
<tr>
<td>4. In the case of considering transferring an activity to an external supplier, how are the administration and material handling costs affected?</td>
<td></td>
</tr>
<tr>
<td>- Is it possible to reduce the number of storage locations?</td>
<td></td>
</tr>
<tr>
<td>- Is it possible to reduce equipment used in the material handling operations?</td>
<td></td>
</tr>
<tr>
<td>- Is it possible to reduce the number of material handling employees?</td>
<td></td>
</tr>
<tr>
<td>- Is it possible to decrease the number of handled articles?</td>
<td></td>
</tr>
<tr>
<td>- How are the supplier base and the ordering procedure affected by the changed make-or-buy setup?</td>
<td></td>
</tr>
<tr>
<td>- How is the total number of orders affected?</td>
<td></td>
</tr>
<tr>
<td>5. In the case of considering transferring an activity to the internal production, how are the administration and material handling cost affected?</td>
<td></td>
</tr>
<tr>
<td>- Is it necessary to increase the storage space?</td>
<td></td>
</tr>
<tr>
<td>- Is it necessary to increase number of handled articles?</td>
<td></td>
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<tr>
<td>- Is it necessary to reduce equipment used in the material handling operations?</td>
<td></td>
</tr>
<tr>
<td>- Is it necessary to increase the number of material handling employees?</td>
<td></td>
</tr>
<tr>
<td>- How are the supplier base and the ordering procedure affected by the changed make-or-buy setup?</td>
<td></td>
</tr>
<tr>
<td>- How is the total number of orders affected?</td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturing costs</strong></td>
<td></td>
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<tr>
<td>6. In the case of considering transferring an activity to an external supplier, how will the manufacturing costs be affected?</td>
<td></td>
</tr>
<tr>
<td>- What is the current production cost for assembling the module in-house?</td>
<td></td>
</tr>
<tr>
<td>- What is the estimated cost for buying the module from an external supplier?</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix 8: Questions to facilitate the total cost evaluation

- Is it possible to achieve economies of scale in the internal production, by transferring the considered activity to an external supplier?
- Is it possible to release any production area?

<table>
<thead>
<tr>
<th>7.</th>
<th>In the case of considering transferring an activity to the internal production, how will the manufacturing costs be affected?</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢</td>
<td>What is the current cost when buying from an external production?</td>
</tr>
<tr>
<td>➢</td>
<td>What is the estimated cost for assembling the module in-house, including material costs?</td>
</tr>
<tr>
<td>➢</td>
<td>What is the estimated cost for acquiring additional production area?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transaction costs</th>
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<tbody>
<tr>
<td>8.</td>
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<tr>
<td>➢</td>
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<tr>
<td>➢</td>
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<tr>
<td>➢</td>
</tr>
</tbody>
</table>

| 9. | In the case of considering transferring an activity to the internal production, how will the bargain and opportunistic costs be affected? |
| ➢ | How is the supplier base affected by the considered option? |
| ➢ | What is the estimated change in time for bargaining and managing the supplier relation for the considered option? |

<table>
<thead>
<tr>
<th>Implementation cost</th>
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</thead>
<tbody>
<tr>
<td>10.</td>
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<tr>
<td>➢</td>
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<tr>
<td>➢</td>
</tr>
</tbody>
</table>
Appendix 9: Questions to facilitate the risk evaluation

<table>
<thead>
<tr>
<th>Question</th>
<th>Step 6a-b: Evaluation of risk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relational risk</strong></td>
<td>1. What is the likelihood and consequence of the relational risk?</td>
</tr>
<tr>
<td></td>
<td>➢ Is there any reason to fear that the supplier will act opportunist, based on prior collaborations?</td>
</tr>
<tr>
<td></td>
<td>➢ Does the supplier act in a competitive or monopolistic market environment?</td>
</tr>
<tr>
<td></td>
<td>➢ How is the power balance relation, between SED and the considered supplier?</td>
</tr>
<tr>
<td></td>
<td>➢ Is there any reason to fear that the distance, or eventual country barriers, to the supplier will invoke a problem?</td>
</tr>
<tr>
<td></td>
<td>➢ Are there any cultural or language related differences that may cause communication problems?</td>
</tr>
<tr>
<td></td>
<td>➢ What is the outcome if the considered risk should occur?</td>
</tr>
<tr>
<td><strong>Operational risk, when collaborating with an external supplier</strong></td>
<td>2. What are the likelihood and consequence of the operational risk, at the external supplier?</td>
</tr>
<tr>
<td></td>
<td>➢ Is there any reason to fear that breakdowns will appear at the supplier’s operations, based on prior collaborations?</td>
</tr>
<tr>
<td></td>
<td>➢ Is any key performance index attainable? If yes, does the statistics indicate that there are reasons to fear breakdowns at the vendors operations and quality shortages?</td>
</tr>
<tr>
<td></td>
<td>➢ How updated is the supplier’s production equipment?</td>
</tr>
<tr>
<td></td>
<td>➢ Does the supplier collaborate with any market-leading firms that are acknowledged as competent?</td>
</tr>
<tr>
<td></td>
<td>➢ What competence and knowledge level are present at the supplier, based on educational level and prior experience?</td>
</tr>
<tr>
<td></td>
<td>➢ What is the outcome if the considered risk should occur?</td>
</tr>
<tr>
<td><strong>Operational risk, when assembling the module in-house</strong></td>
<td>3. What are the likelihood and consequence of the operational risk in-house?</td>
</tr>
<tr>
<td></td>
<td>➢ Is there any reason to fear that breakdowns will appear at SED’s internal operations?</td>
</tr>
<tr>
<td></td>
<td>➢ Is any key performance index attainable? If yes, does the statistics indicate that there are reasons to fear breakdowns at the vendors operations and quality shortages?</td>
</tr>
<tr>
<td></td>
<td>➢ How updated is SED’s production equipment?</td>
</tr>
<tr>
<td></td>
<td>➢ What competence and knowledge level are present at SED, based on educational level and prior experience?</td>
</tr>
<tr>
<td></td>
<td>➢ What is the outcome if the considered risk should occur?</td>
</tr>
<tr>
<td><strong>Loss of knowledge</strong></td>
<td>4. How is the risk of losing knowledge affected by the make-or-buy decision?</td>
</tr>
<tr>
<td></td>
<td>➢ Will the internal staff perform similar tasks, if the considered activity is transferred to an external supplier?</td>
</tr>
<tr>
<td></td>
<td>➢ Will the internal staff still be involved in the research and development of the considered activity, thus still being part of the manufacturing process?</td>
</tr>
</tbody>
</table>
### Appendix 9: Questions to facilitate the risk evaluation

- What level of documentation is available for the considered activity?
- What is the outcome if the considered risk should occur?

### Too dependent on supplier

5. What are the likelihood and consequence of the risk to become too dependent on the supplier?
   - Does the considered activity concern scarce and critical resources?
   - Has any previous collaboration generated problems due to SED being too dependent on the supplier, historically?
   - Is there any reason to fear that the supplier is unwilling or unable to adapt new technology or make other investments?
   - What is the outcome if the considered risk should occur?
   - Is there any reason to fear that the supplier will become dependent on SED as a customer and hence make it morally wrong to leave the business relationship?

### Imitation by competitors

6. What are the likelihood and consequence of the risk that competitors will imitate internal operations, which can result in loss of competitive advantage?
   - Is there any reason to fear that the supplier lack the ability to be confidential?
   - Is it necessary to share critical knowledge and information with the supplier, in the considered make-or-buy setup?
   - What is the outcome if the considered risk should occur?

### Legal risk

7. What are the likelihood and consequence of legal risk in the considered make-or-buy setup?
   - Has any previous collaboration involved legal problems, historically?
   - In which country is the potential supplier located?
   - What is the outcome if the considered risk should occur?

### Loss of control

8. What are the likelihood and consequence of the risk to lose control, in the considered make-or-buy setup?
   - Is it likely that the risk of losing control will increase when implementing the considered make-or-buy setup?
   - How is the power balance relation, between SED and the considered supplier?
   - Are there clear working instructions at SED?
   - Are there incitements for following these instructions?
   - What is the outcome if the considered risk should occur?

### Supply disturbances

9. What are the likelihood and consequence of the risk supply disturbances, in the considered make-or-buy setup?
   - What effect would a supply deficiency caused by the considered supplier have on SED’s internal production?
   - Based on historical data, it is likely that supply disturbances will occur?
   - What prerequisites for quickly fixing the supply deficiency does the considered supplier have?
# Appendix 10: Questions to facilitate the evaluation of remaining parameters

## Step 7a: Evaluation of remaining parameters

### Time flexibility

1. **Is it possible to achieve a higher degree of time-flexibility trough collaborating with an external supplier?**
   - Are there any routines for rush-orders at SED and the potential supplier?
   - Are there routines for quickly handling time-critical changes at SED and the potential supplier?
   - How service-minded is the considered supplier?
   - How is the power balance relation between SED and the potential supplier?
   - Is SED an important customer for the supplier, standing for a considerable ratio of the supplier’s total turnover?
   - What internal possibilities regarding time flexibility exists at SED?

### Impact on R&D operations

2. **In the case of considering transferring an activity to an external supplier, how will the R&D operations be affected?**
   - According to statistics, is there any difference in quality related costs when producing the module in-house versus production at an external supplier?
   - Is there any difference in how time consuming the error searching and correcting operations are, when producing the module in-house versus production at an external supplier?
   - What proactive actions are taken by the supplier in order to reduce quality delimitations?
   - How well has the supplier performed historically, in the instances where such statistic is available?
   - How will the communication and work effort be affected, when implementing product and quality related changes, by the make-or-buy decision?
   - Is it possible to improve the manufacturing process by collaborating with an external supplier?

3. **In the case of considering transferring an activity to the internal production, how will the R&D operations be affected?**
   - According to statistics, is there any difference in quality related costs when producing the module in-house versus production at an external supplier?
   - Is there any difference in how time consuming the error searching and correcting operations are, when producing the module in-house versus production at an external supplier?
   - How will the communication and work effort be affected, when implementing product and quality related changes, by the make-or-buy decision?
   - Is it likely that improvements of the manufacturing process will be lost, by not collaborating with an external supplier?
### Acquiring competitive knowledge

**4.** Is it possible to achieve competitive knowledge, apart from knowledge concerning production of the considered module, through transferring an activity to an external supplier?

- Has any previous collaborations generated access of knowledge that is useful in a broader perspective at the firm, historically?
- Does the supplier possess higher or broader knowledge in any area or aspect?
- Does the supplier’s culture encourage inter-firm collaborations and knowledge transfer?

### Product flexibility

**5.** Is it possible to achieve higher product flexibility trough a change make-or-buy setup?

- How asset specific is the considered module?
- Which party owns the specific asset?

### Opportunity to share risk

**6.** Is it possible to reduce any risks by sharing them?

- Does collaboration with an external supplier enable SED to avoid investments in any technology or equipment?
- Is it possible to reduce any other risks by sharing them with the supplier?
- Is it likely that any risks will increase, if the considered module is transferred to the internal production?

### Long-term capacity

**7.** Is it possible to achieve a higher degree of long-term capacity by collaborating with an external supplier?

- Does the considered supplier possess investments or unused assets that enable them to increase their capacity in the long run?
- Has the considered supplier increased their production, historically?
- Is there any other reasons to believe that the considered supplier have the ability to increase their long-term capacity?